

THE COMPLETE PATENTS OF NIKOLA TESLA

(WELL NEARLY)

THE COMPLETE PATENTS OF NIKOLA TESLA

Edited by JIM GLENN

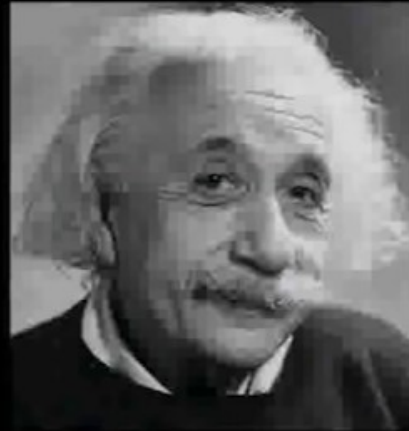
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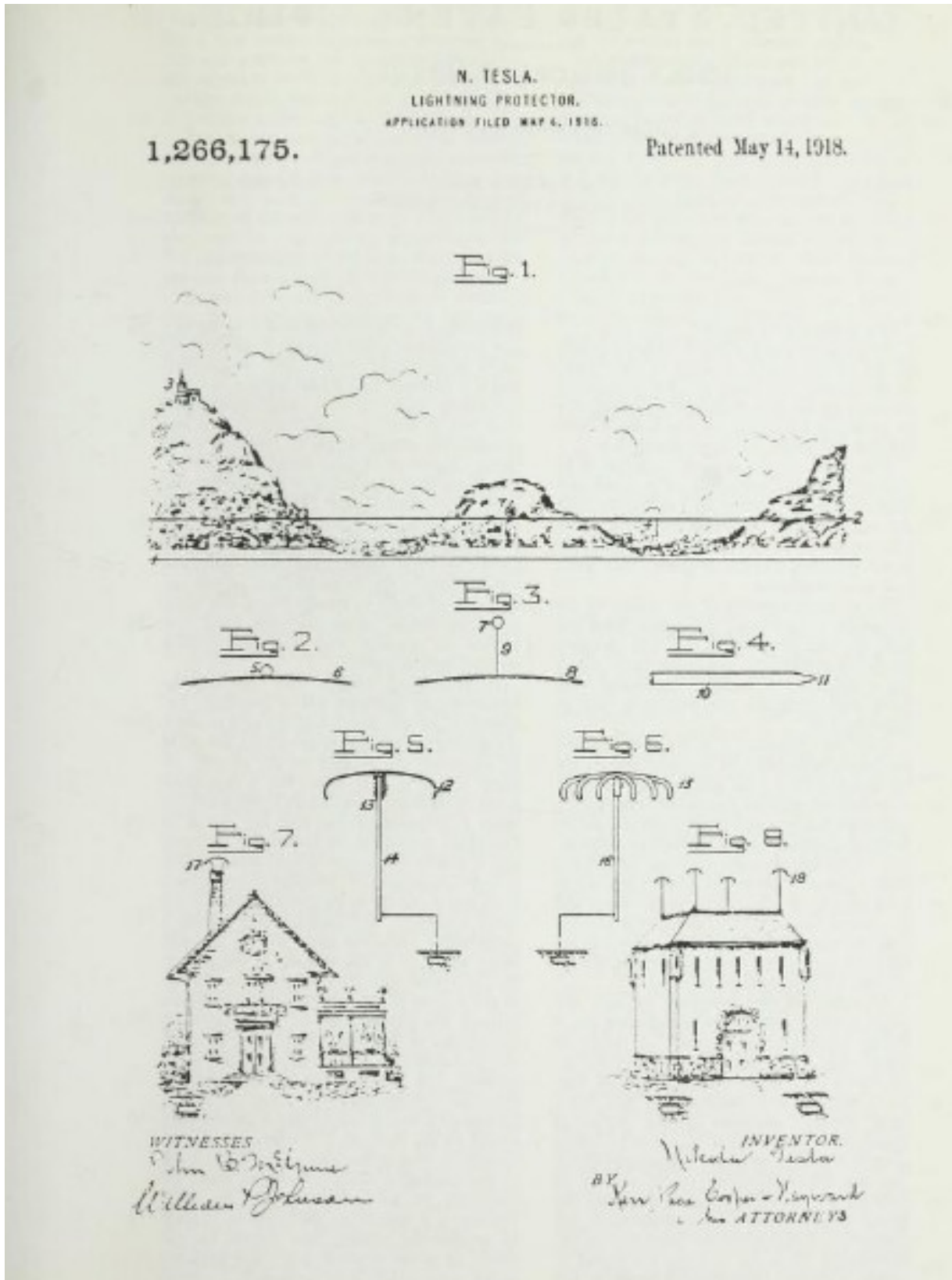
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Einstein was once asked how it felt to be the smartest man alive. Einstein's reply was "I don't know, you'll have to ask Nikola Tesla."



The Mind Unleashed

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the piston have been shown merely by way of
130 suggestion and can be dispensed with. Each
of the chambers 15 and 16 being connected
to two conduits as illustrated, the vibrations
of a solid piston as 8 will have the same effect
and the machine will then be a double acting
235 pump or compressor. It is likewise unessential
that the medium should be admitted to the
cylinder through such devices for in certain
instances ports, alternately closed and opened
by the piston, may serve the purpose. As a
240 matter of course, this novel method of propelling
fluids can be extended to multistage working
in which case a number of pistons will be
employed, preferably on the same shaft and
of different diameters in conformity with well
245 established principles of mechanical design. In
this way any desired ratio of compression or
degree of rarefaction may be attained.

Fig. 4 exemplifies a particularly valuable application
of the invention to which reference
250 has been made above. The drawing shows in
vertical cross section a turbine which may be
of any type but is in this instance one invented
and described by me and supposed to be familiar
to engineers. Suffice it to state that the
255 rotor 21 of the same is composed of flat plates
which are set in motion through the adhesive
and viscous action of the working fluid, entering
the system tangentially at the periphery and leaving
it at the center. Such a machine
260 is a thermodynamic transformer of an activity
surpassing by far that of any other prime mover,
it being demonstrated in practice that each single
disk of the rotor is capable of performing as much
work as a whole bucket-wheel. Besides, a number
265 of other advantages, equally important, make it
especially adapted for operation as an internal
combustion motor. This may be done in many
ways, but the simplest and most direct plan of
which I am
270 aware is the one illustrated here. Referring
again to the drawing, the upper part of the
turbine casing 22 has bolted to it a separate
casing 23, the central cavity 24 of which forms
the combustion chamber. To prevent
275 injury through excessive heating a jacket 25
may be used, or else water injected, and when
these means are objectionable recourse may be
had to air cooling, this all the more readily as

be in communication with a ventilator, preferably
carried on the same shaft and of any suitable
295 construction. Its use, however, while
advantageous, is not indispensable the suction
produced by the turbine rotor itself being, in
some cases at least, sufficient to insure proper
working. This detail is omitted from the drawing
300 as unessential to the understanding.

But a few words will be needed to make
clear the mode of operation. The air valve 30
being open and sparking established across terminals
27, the gas is turned on slowly until
305 the mixture in the chamber 24 reaches the
critical state and is ignited. Both the conduits
behaving, with respect to efflux, as closed
valves, the products of combustion rush out
through the nozzle 29 acquiring still greater
310 velocity by expansion and, imparting their
momentum to the rotor 21, start it from rest.
Upon the subsidence of the explosion the
pressure in the chamber sinks below the atmospheric
owing to the pumping action of the
315 rotor or ventilator and new air and gas is
permitted to enter, cleaning the cavity and
channels and making up a fresh mixture which
is detonated as before, and so on, the successive
impulses of the working fluid producing an
320 almost continuous rotary effort. After a short
lapse of time the chamber becomes heated to
such a degree that the ignition device may be
shut off without disturbing the established
régime. This manner of starting the turbine
325 involves the employment of an unduly large
combustion chamber which is not commendable
from the economic point of view, for not only
does it entail increased heat losses but the
explosions cannot be made to follow one
330 another with such rapidity as would be desirable
to insure the best valvular action. When the
chamber is small an auxiliary means for starting,
as compressed air, may be resorted to and a
very quick succession of explosions
335 can then be obtained. The frequency will be
the greater the stronger the suction, and may,
under certain conditions, reach hundreds and
even thousands per second. It scarcely need
be stated that instead of one several explosion
340 chambers may be used for cooling purposes
and also to increase the number of active
pulses and the output of the machine.

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so easily to this improvement that an enlarge-
360 ment on this subject is deemed unnecessary.

The foregoing description will readily suggest to experts modifications both as regards construction and application of the device and I do not wish to limit myself in these respects.

365 The broad underlying idea of the invention is to permit the free passage of a fluid through a channel in the direction of the flow and to prevent its return through friction and mass resistance, thus enabling the performance of
370 valve functions without any moving parts and thereby extending the scope and usefulness of an immense variety of mechanical appliances.

I do not claim the methods of and apparatus for the propulsion of fluids and thermodynamic
375 transformation of energy herein disclosed, as these will be made subjects of separate applications.

I am aware that asymmetrical conduits have been constructed and their use proposed in
380 connection with engines, but these have no similarity either in their construction or manner of employment with my valvular conduit. They were incapable of acting as valves proper, for the fluid was merely arrested in pockets
385 and deflected through 90° , this result having at best only 25% of the efficiency attained in the construction herein described. In the conduit I have designed the fluid, as stated above, is deflected in each cycle through 360° , and a
390 co-efficient approximating 200 can be obtained so that the device acts as a slightly leaking valve, and for that reason the term "valvular" has been given to it in contrast to asymmetrical conduits, as heretofore proposed, which
395 were not valvular in action, but merely asymmetrical as to resistance.

Furthermore, the conduits heretofore constructed were intended to be used in connection with slowly reciprocating machines, in
400 which case enormous conduit-length would be necessary, all this rendering them devoid of practical value. By the use of an effective valvular conduit, as herein described, and the employment of pulses of very high frequency, I
405 am able to condense my apparatus and secure such perfect action as to dispense successfully with valves in numerous forms of reciprocating and rotary engines.

meet with a relative speed, twice that of the flow, and the energy of their impact is four
425 times greater than with a deflection of only 90° , as might be obtained with pockets such as have been employed in asymmetrical conduits for various purposes. The fact is, however, that in these such deflection is not
430 secured, the pockets remaining filled with comparatively quiescent fluid and the latter following a winding path of least resistance between the obstacles interposed. In such conduits the action cannot be characterized as
435 "valvular" because some of the fluid can pass almost unimpeded in a direction opposite to the normal flow. In my construction, as above indicated, the resistance in the reverse may be
440 200 times that in the normal direction. Owing to this a comparatively very small number of buckets or elements is required for checking the fluid. To give a concrete idea, suppose that the leak from the first element is represented
445 by the fraction $\frac{1}{x}$, then after the n th bucket is traversed, only a quantity $(\frac{1}{x})^n$ will escape and it is evident that x need not be a large number to secure a nearly perfect valvular action.

What I claim is:

450 1. A valvular conduit having interior walls of such conformation as to permit the free passage of fluid through it in the direction of flow but to subject it to rapid reversals of direction when impelled in the opposite sense
455 and thereby to prevent its return by friction and mass resistance.

2. A valvular conduit composed of a closed passageway having recesses in its walls so
460 formed as to permit a fluid to pass freely through it in the direction of flow, but to subject it to rapid reversals of direction when impelled in an opposite sense and thereby interpose friction and mass resistance to the return
465 passage of the same.

3. A valvular conduit composed of a tube or passageway with rigid interior walls formed with a series of recesses or pockets with surfaces that reverse a fluid tending to flow in
470 one direction therein and thereby check or prevent flow of the fluid in that direction.

4. A valvular conduit with rigid interior walls of such character as to offer substantially

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UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y.

VALVULAR CONDUIT.

1,329,559.

Specification of Letters Patent.

Patented Feb. 3, 1920.

Application filed February 21, 1916. Serial No. 79,703. Renewed July 8, 1919. Serial No. 309,482.

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have
5 invented certain new and useful Improvements in Valvular Conduits, of which the following is a full, clear, and exact description.

In most of the machinery universally employed for the development, transmission and
10 transformation of mechanical energy, fluid impulses are made to pass, more or less freely, through suitable channels or conduits in one direction while their return is effectively checked or entirely prevented. This function
15 is generally performed by devices designated as valves, comprising carefully fitted members the precise relative movements of which are essential to the efficient and reliable operation of the apparatus. The necessity of, and absolute
20 dependence on these, limits the machine in many respects, detracting from its practical value and adding greatly to its cost of manufacture and maintenance. As a rule the valve is a delicate contrivance, very liable to wear
25 and get out of order and thereby imperil ponderous, complex and costly mechanism and, moreover, it fails to meet the requirements when the impulses are extremely sudden or rapid in succession and the fluid is highly
30 heated or corrosive.

Though these and other correlated facts were known to the very earliest pioneers in

passage of the fluid in one direction, other
than surface friction, constitute an almost im-
passable barrier to its flow in the opposite
sense by reason of the more or less sudden
expansions, contractions, deflections, reversals
of direction, stops and starts and attendant
35 rapidly succeeding transformations of the pressure and velocity energies.

For the full and complete disclosure of the device and of its mode of action reference is made to the accompanying drawings in
60 which—

Figure 1 is a horizontal projection of such a valvular conduit with the top plate removed.

Fig. 2 is side view of the same in elevation.

Fig. 3 is a diagram illustrative of the applica-
65 tion of the device to a fluid propelling machine such as, a reciprocating pump or compressor, and

Fig. 4 is a plan showing the manner in which the invention is, or may be used, to
70 operate a fluid propelled rotary engine or turbine.

Referring to Fig. 1, 1 is a casing of metal or other suitable material which may be cast, milled or pressed from sheet in the desired
75 form. From its side-walls extend alternatively projections terminating in buckets 2 which, to facilitate manufacture are congruent and spaced at equal distances, but need not be. In addition to these there are independent partitions
80 3 which are deemed of advantage and the pur-

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TESLA

site end 4. In this case the flow will not be
100 smooth and continuous, but intermittent, the
fluid being quickly deflected and reversed in
direction, set in whirling motion, brought to
rest and again accelerated, these processes fol-
105 lowing one another in rapid succession. The
partitions 3 serve to direct the stream upon
the buckets and to intensify the actions caus-
ing violent surges and eddies which interfere
very materially with the flow through the con-
duit. It will be readily observed that the resis-
110 tance offered to the passage of the medium
will be considerable even if it be under con-
stant pressure, but the impediments will be of
full effect only when it is supplied in pulses
and, more especially, when the same are ex-
115 tremely sudden and of high frequency. In
order to bring the fluid masses to rest and to
high velocity in short intervals of time energy
must be furnished at a rate which is unattain-
able, the result being that the impulse cannot
120 penetrate very far before it subsides and gives
rise to movement in the opposite direction.
The device not only acts as a hinderment to
the bodily return of particles but also, in a
measure, as a check to the propagation of a
125 disturbance through the medium. Its efficacy
is chiefly determined; first, by the magnitude
of the ratio of the two resistances offered to
disturbed and to undisturbed flow, respec-
tively, in the directions from 4 to 5 and from
130 5 to 4, in each individual element of the con-
duit; second, by the number of complete cy-
cles of action taking place in a given length
of the valvular channel and, third, by the char-
acter of the impulses themselves. A fair idea may
135 be gained from simple theoretical considera-
tions.

Examining more closely the mode of opera-
tion it will be seen that, in passing from one
to the next bucket in the direction of dis-
140 turbed flow, the fluid undergoes two complete
reversals or deflections through 180 degrees
while it suffers only two small deviations from
about 10 to 20 degrees when moving in the
opposite sense. In each case the loss of head
145 will be proportionate to a hydraulic coefficient
dependent on the angle of deflection from

because the successive actions diminish in in-
tensity. Definite limits, however, are set con- 165
structively and otherwise to the number of
elements per unit length of the channel, and
the most economical design can only be
evolved through long experience.

Quite apart from any mechanical features 170
of the device the character of the impulses has
a decided influence on its performance and
the best results will be secured, when there are
produced at 4, sudden variations of pressure
in relatively long intervals, while a constant 175
pressure is maintained at 5. Such is the case in
one of its most valuable industrial applications
which will be specifically described.

In order to conduce to a better understand-
ing, reference may first be made to Fig. 3 180
which illustrates another special use and in
which 8 is a piston fixed to a shaft 9 and
fitting freely in a cylinder 10. The latter is
closed at both ends by flanged heads 11 and
12 having sleeves or stuffing boxes 13 and 185
14 for the shaft. Connection between the two
compartments, 15 and 16, of the cylinder is
established through a valvular conduit and
each of the heads is similarly equipped. For
the sake of simplicity these devices are dia- 190
grammatically shown, the solid arrows indicat-
ing the direction of undisturbed flow. An
extension of the shaft 9 carries a second piston
17 accurately ground to and sliding easily in
a cylinder 18 closed at the ends by plates and 195
sleeves as usual. Both piston and cylinder are
provided with inlet and outlet ports marked,
respectively, 19 and 20. This arrangement is
familiar, being representative of a prime mover
of my invention, termed "mechanical oscilla- 200
tor", with which it is practicable to vibrate a
system of considerable weight many thousand
times per minute.

Suppose now that such rapid oscillations are
imparted by this or other means to the piston 205
8. Bearing in mind the proceeding, the opera-
tion of the apparatus will be understood at a
glance. While moving in the direction of the
solid arrow, from 12 to 11, the piston 8 will
compress the air or other medium in the com- 210
partment 16 and expel it from the same, the

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of that delivered per minute will be, generally,
100 sufficient. Such a cascade presents a singularly
attractive appearance and this feature may be
still further enhanced by artistic grouping of
plants or other objects around it, in which case
the whole contrivance may be hidden from
105 view. Particularly beautiful displays, however,
are obtainable by illumination which may be
carried out in many ways. To heighten the
effect, a colored, opalescent or phosphorescent
fluid may be employed. Sterilizing, aromatic
110 or radio-active liquids may also be used, when
so desired. The usual fountains are objection-
able in many places on account of the facility
they afford for the breeding of insects. The
apparatus described not only makes this im-
115 possible but is a very efficient trap. Unlike the
old devices in which only a very small volume
of water is set in motion, such a waterfall is
highly effective in cooling the surrounding at-
mosphere. To still improve this action the free
120 end 13 of the rotating shaft may be utilized
to carry any kind of fan. The water may, of
course, be artificially cooled.

The device described may be modified in
many ways and also considerably simplified.
125 For example, the propeller may be fixed di-
rectly to the shaft of the motor and the latter
supported conveniently from above when
many of the parts illustrated in Fig. 1 and Fig.
2 may be dispensed with. In fact, receptacle
130 1 itself may be replaced by an independent
tank or basin so that the entire apparatus will
only consist of a funnel shaped conduit, motor
and propeller as a unit. Such a construction
is shown in Fig. 3 and Fig. 4 in which 3 is a
135 conical vessel provided with intake openings 4
and resting on a substantial base. A motor 14,
carrying on a strong shaft 5 a propeller 9, is
fixed to supports 15 which extend from the
inner side of conduit 3 and may be integral
140 with the same. Obviously, to insure perfect
working the weight of the moving parts and
axial reaction of the propeller should be taken
up or balanced as by a thrust bearing 16, or
other means.

145 Apparatus of this description is especially
adapted for use in warm localities or countries

old and well known. But in all such cases
independent pumps of small volumetric capac-
ity were used to raise the water to an approx- 165
imate height which involved the expenditure
of considerable energy, while the spectacle of-
fered to the eye was uninteresting. In no in-
stance, to my knowledge, has a great mass of
fluid been propelled by the use of only such 170
power as is required to lift it from its normal
level through a relatively short space to that
from which it overflows and descends as a
cascade, nor have devices especially adapted
for the purpose been employed. 175

What I claim is:

1. An artificial fountain consisting of an un-
obstructed conduit having an elevated over-
flow and adapted to be set in a body of water,
and a propelling device for maintaining a 180
rapid circulation of the water through the
conduit.

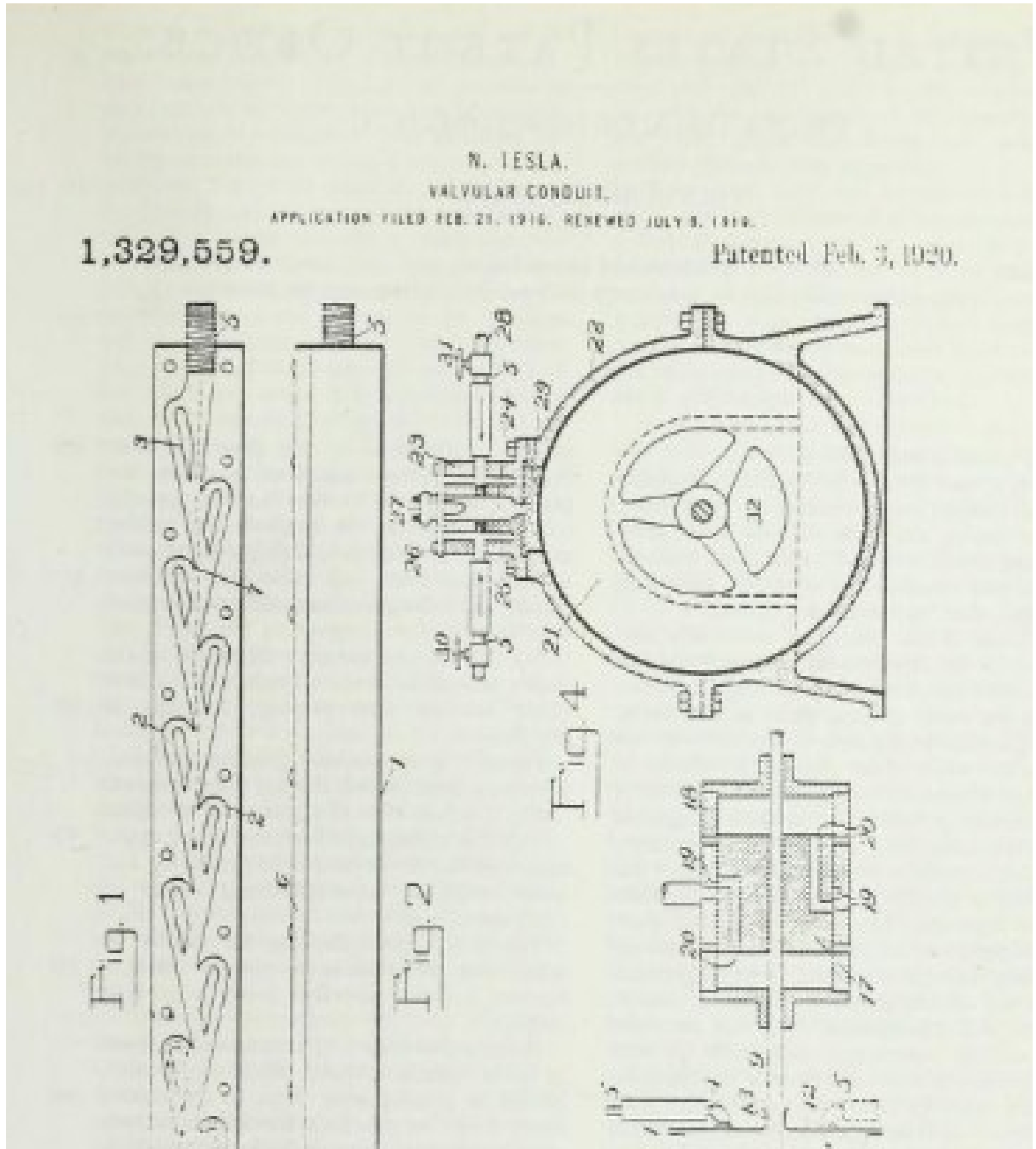
2. An artificial fountain comprising in com-
bination an unobstructed conduit having an
elevated overflow and adapted to be set in a 185
body of fluid, a propeller within the conduit
for maintaining a rapid circulation of the fluid
through the same, and a motor for driving
the propeller.

3. The artificial fountain herein described, 190
comprising in combination a receptacle, a cen-
tral hollow conduit with an elevated overflow
placed therein, a propeller within the conduit,
and a motor for driving the propeller, so as to
maintain a rapid circulation of fluid through 195
the conduit.

4. The artificial fountain herein described,
comprising in combination, a receptacle, a
conduit with elevated overflow set therein, a
central hub extending up through the conduit, 200
a rotary shaft extending therethrough, and a
propeller carried by the shaft for maintaining a
rapid circulation of fluid through the conduit.

5. An artificial fountain comprising in com-
bination with an unobstructed passage from 205
the normal to the elevated fluid levels, of a
propeller for maintaining a rapid circulation of
the fluid through such passage and producing
thereby a cascade with the expenditure of lit-
tle energy.

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UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y.

FOUNTAIN.

1,113,716.

Specification of Letters Patent.

Patented Oct. 13, 1914.

Application filed October 26, 1913. Serial No. 797,718.

To whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, borough of Manhattan, county and State of New York, have invented certain new and useful Improvements in Fountains, of which the following is a full, clear, and exact description.

It has been customary heretofore in fountains and aquarian displays, to project spouts, jets, or sprays of water from suitable fixtures, chiefly for decorative and beautifying purposes. Invariably, the quantity of the issuing fluid was small and the pleasing impression on the eye was solely the result of the more or less artistic arrangement of the streamlets and ornaments employed. The present invention is a departure from such practice in that it relies principally on the fascinating spectacle of a large mass of fluid in motion and the display of seemingly great power. Incidentally, it permits the realization of beautiful and striking views through illumination and the disposition of voluminous cascades which, moreover, may be applied to useful purposes in ways not practicable with the old and familiar devices. These objects are accomplished by the displacement of a great volume of fluid with a relatively small expenditure of energy in the production and maintenance of a veritable waterfall as distinguished from a mere spout, jet or spray.

The underlying idea of the invention can

6 and carrying at its lower end a friction pulley or gear wheel 7. To the upper end of the shaft is fastened a casting 8, preferably of some non-corrosive alloy, with blades 9 constituting a screw which is shown in this instance as the best known propelling device; but it will be understood that other means may be employed. A motor 10 is suitably mounted so as to transmit through wheel 11, by friction or otherwise, power to the pulley or wheel 7. Openings 4 may be covered with removable strainers and receptacles 1 may be provided with convenient connections, respectively, for cleaning and renewing the liquid. It is thought unnecessary to show these attachments in the drawing.

The operation will be readily understood. Receptacle 1 being filled to the proper level with water or other fluid, and the power turned on, the propeller blades 9 are set in rotation and the fluid, drawn through the openings 4, is lifted to the horizontal flared out top of conduit 3 until it overflows in the form of a circular cascade.

In order to prevent the wearing of the bearings of shaft 5, the central hub 2 of receptacle 1 is made to project above conduit 3. The latter is funnel shaped for reasons of economy, and also for the purpose of reducing the speed and securing a smooth and even overflow. As the lift is inconsiderable, little power is needed to keep in motion a great volume of water

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1,113,716.

N. TESLA.
FOUNTAIN.

APPLICATION FILED OCT. 23, 1913

Patented Oct. 13, 1914.

2 SHEETS SHEET 2

Fig. 3.

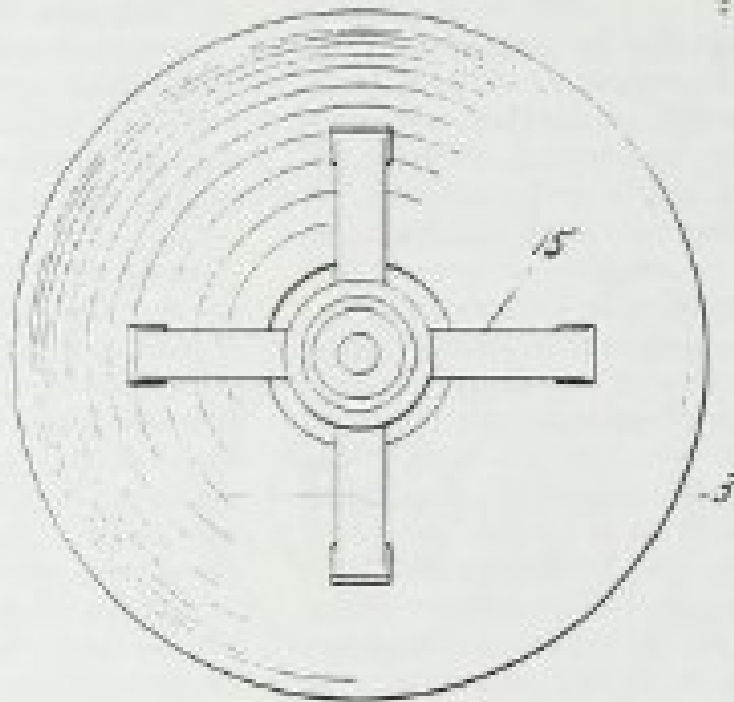
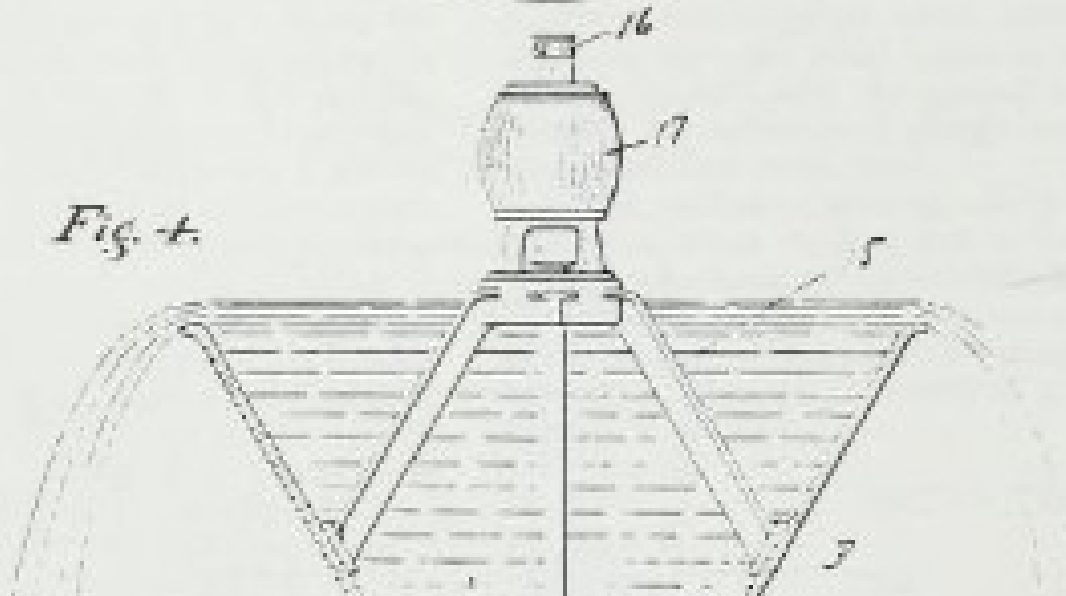


Fig. 4.



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charge to the plate P and condenser-terminal
130 T, while terminal T' is continuously receiving
negative electricity from the plate P'. This, as
before explained, results in an accumulation
of electrical energy in the condenser, which
goes on as long as the circuit including the
135 primary p is interrupted. Whenever the circuit
is closed, owing to the rotation of the terminal
 t , the stored energy is discharged through the
primary p , this giving rise in the secondary s to
induced currents which operate the receiver R.
140 It is clear from what has been stated above
that if the terminal T' is connected to a plate
supplying positive instead of negative electric-
ity the rays should convey negative electricity
to plate P. The source S may be any form of
145 Roentgen or Lenard tube; but it is obvious
from the theory of action that in order to be
very effective the electrical impulses exciting it
should be wholly or at least preponderatingly
of one sign. If ordinary symmetrical alternat-
150 ing currents are employed, provision should
be made for allowing the rays to fall upon the
plate P only during those periods when they
are productive of the desired result. Evidently
if the radiations of the source be stopped or
155 intercepted or their intensity varied in any
manner, as by periodically interrupting or
rhythmically varying the current exciting the
source, there will be corresponding changes in
the action upon the receiver R, and thus sig-
160 nals may be transmitted and many other use-
ful effects produced. Furthermore, it will be
understood that any form of circuit-closer
which will respond to or be set in operation
when a predetermined amount of energy is
165 stored in the condenser may be used in lieu
of the device specifically described with refer-
ence to Fig. 1, and also that the special details
of construction and arrangement of the several
parts of the apparatus may be very greatly var-
170 ied without departure from the invention.

Having described my invention, what I
claim is—

1. The method of utilizing radiant energy,
which consists in charging one of the arma-

175 tures of a condenser by rays or radiations, and
the other armature by independent means,
and discharging the condenser through a suit-
able receiver, as set forth.

2. The method of utilizing radiant energy,
which consists in simultaneously charging a 280
condenser by means of rays or radiations and
an independent source of electrical energy, and
discharging the condenser through a suitable
receiver, as set forth.

3. The method of utilizing radiant energy, 285
which consists in charging one of the arma-
tures of a condenser by rays or radiations, and
the other by independent means, controlling
the action or effect of said rays or radiations
and discharging the condenser through a suit- 290
able receiver, as set forth.

4. The method of utilizing radiant energy,
which consists in charging one of the arma-
tures of a condenser by rays or radiations and
the other by independent means, varying the 295
intensity of the said rays or radiations and
periodically discharging the condenser through
a suitable receiver, as set forth.

5. The method of utilizing radiant energy,
which consists in directing upon an elevated 300
conductor, connected to one of the armatures
of a condenser, rays or radiations capable of
positively electrifying the same, carrying off
electricity from the other armature by con- 305
necting the same with the ground, and dis-
charging the accumulated energy through a
suitable receiver, as set forth.

6. The method of utilizing radiant energy,
which consists in charging one of the arma-
tures of a condenser by rays or radiations, and 310
the other by independent means, and effecting
by the automatic discharge of the accumulated
energy the operation or control of a suitable
receiver, as set forth.

NIKOLA TESLA.

WITNESSES:

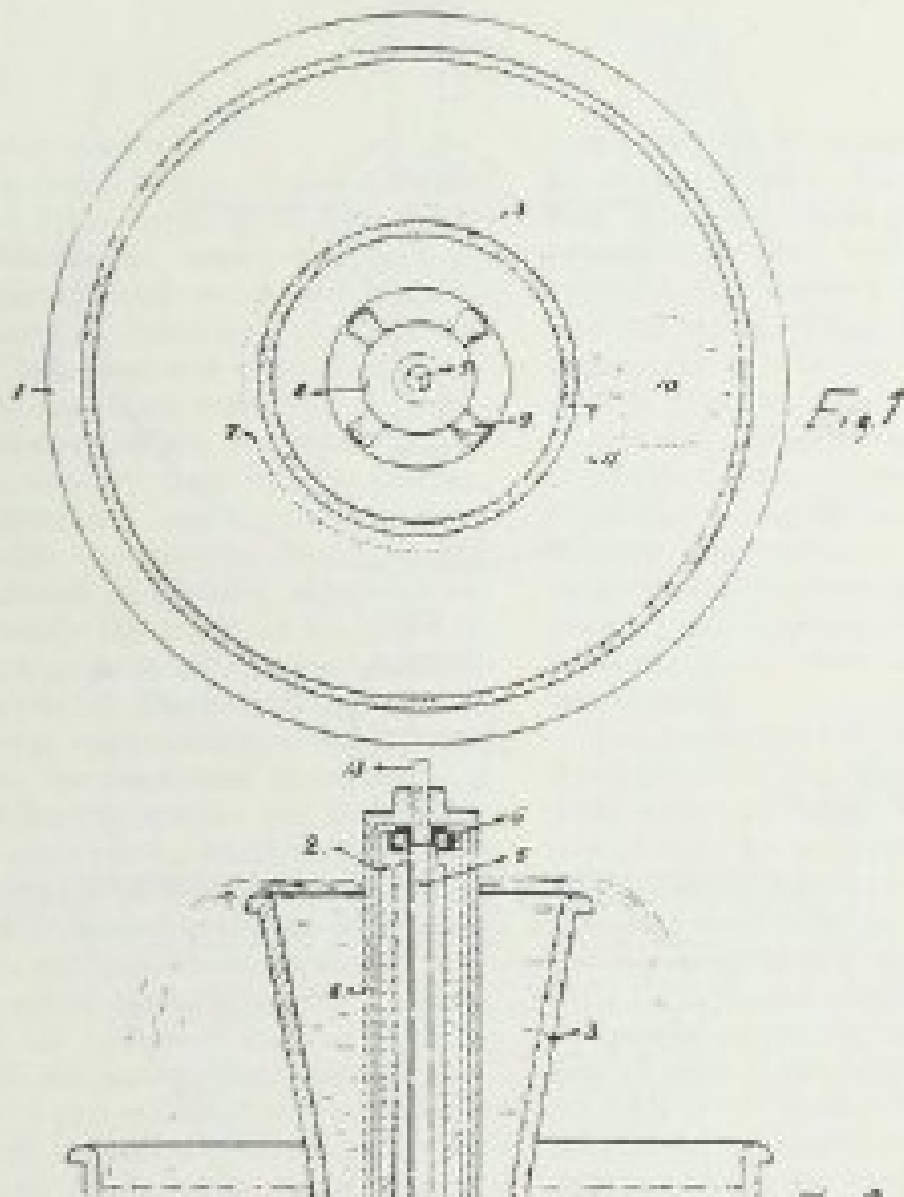
M. LAWSON DYER,
RICHARD DONOVAN.

THE COMPLETE PATENTS OF NIKOLA TESLA

N. TESLA.
FOUNTAIN
APPLICATION FILED OCT. 18, 1913

1,113,716.

Patented Oct. 13, 1914.
2 SHEETS-SHEET 1.



THE COMPLETE PATENTS OF NIKOLA TESLA

UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y.

METHOD OF UTILIZING RADIANT ENERGY.

SPECIFICATION forming part of Letters Patent No. 685,958, dated November 5, 1901.

Application filed March 21, 1901. Serial No. 52,154. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at the borough of Manhattan, in the city, county, and State of New York, have invented certain new and useful Improvements in Methods of Utilizing Radiant Energy, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

It is well known that certain radiations—such as those of ultra-violet light, cathodic, Roentgen rays, or the like—possess the property of charging and discharging conductors of electricity, the discharge being particularly noticeable when the conductor upon which the rays impinge is negatively electrified. These radiations are generally considered to be either vibrations of extremely small wave lengths, and in explanation of the phenomena noted it has been assumed by some authorities that they ionize or render conducting the atmosphere through which they are propagated. My own experiments and observations, however, lead me to conclusions more in accord with the theory heretofore advanced by me that sources of such radiant energy throw off with great velocity minute particles of matter which are strongly electrified, and therefore capable of charging an electrical conductor, or even if not so may at any rate discharge an electrified conductor either by carrying off bodily its charge or otherwise.

My present application is based upon a dis-

of mechanical or electrical devices or rendered useful in many other ways.

In applying my discovery I provide a condenser, preferably of considerable electrostatic capacity, and connect one of its terminals to an insulated metal plate or other conducting body exposed to the rays or streams of radiant matter. It is very important, particularly in view of the fact that electrical energy is generally supplied at a very slow rate to the condenser, to construct the same with the greatest care. I use by preference the best quality of mica as dielectric, taking every possible precaution in insulating the armatures, so that the instrument may withstand great electrical pressures without leaking and may leave no perceptible electrification when discharging instantaneously. In practice I have found that the best results are obtained with condensers treated in the manner described in a patent granted to me February 23, 1897, No. 577,671. Obviously the above precautions should be the more rigorously observed the slower the rate of charging and the smaller the time interval during which the energy is allowed to accumulate in the condenser. The insulated plate or conducting body should present as large a surface as practicable to the rays or streams of matter, I having ascertained that the amount of energy conveyed to it per unit of time is under otherwise identical conditions proportionate to the area exposed, or nearly so. Furthermore, the surface should be clean and

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condenser-terminal, which is connected to the
100 plate or conductor above mentioned, I usually
connect the second terminal of the condenser
to the ground, this being the most convenient
way of obtaining negative electricity, dispens-
ing with the necessity of providing an artificial
105 source. In order to utilize for any useful pur-
pose the energy accumulated in the condenser,
I furthermore connect to the terminals of the
same a circuit including an instrument or ap-
paratus which it is desired to operate and an-
110 other instrument or device for alternately
closing and opening the circuit. This latter
may be any form of circuit-controller, with
fixed or movable parts or electrodes, which
may be actuated either by the stored energy
115 or by independent means.

The rays or radiations which are to be uti-
lized for the operation of the apparatus above
described in general terms may be derived
from a natural source, as the sun, or may be
120 artificially produced by such means, for exam-
ple, as an arc-lamp, a Roentgen tube, and the
like, and they may be employed for a great
variety of useful purposes.

My discovery will be more fully understood
125 from the following detailed description and
annexed drawings, to which reference is now
made, and in which—

Figure 1 is a diagram showing typical forms
of the devices or elements as arranged and
130 connected in applying the method for the op-
eration of a mechanical contrivance or instru-
ment solely by the energy stored; and Fig. 2 is
a diagrammatical representation of a modified
arrangement suitable for special purposes, with
135 a circuit-controller actuated by independent
means.

Referring to Fig. 1, C is the condenser, P
the insulated plate or conducting body, which
is exposed to the rays, and P' another plate or
140 conductor, all being joined in series, as shown.
The terminals T T' of the condenser are also
connected to a circuit including a receiver R,
which is to be operated, and a circuit-
controlling device A, which in this case is com-
145 posed of two very thin, conducting-plates t t',
placed in close proximity and very mobile, ei-
ther by reason of extreme flexibility or owing
to the character of their support. To improve

particles of matter positively electrified, which,
impinging upon the plate P, communicate an 165
electrical charge to the same. The opposite ter-
minal of the condenser being connected to the
ground, which may be considered as a vast
reservoir of negative electricity, a feeble cur-
rent flows continuously into the condenser, 170
and inasmuch as these supposed particles are
of an inconceivably small radius or curvature,
and consequently charged to relatively very
high potential, this charging of the condenser
may continue, as I have found in practice, 175
almost indefinitely, even to the point of rup-
turing the dielectric. Obviously whatever
circuit-controller be employed it should oper-
ate to close the circuit in which it is included
when the potential in the condenser has 180
reached the desired magnitude. Thus in Fig.
2 when the electrical pressure at the terminals
T T' rises to a certain predetermined value the
plates t t', attracting each other, close the cir-
cuit connected to the terminals. This permits 185
a flow of current which energizes the magnet
M, causing it to draw down the armature a
and impart a partial rotation to the ratchet-
wheel w. As the current ceases the armature
is retracted by the spring b without, however, 190
moving the wheel w. With the stoppage of
the current the plates t t' cease to be attracted
and separate, thus restoring the circuit to its
original condition.

Many useful applications of this method of 195
utilizing the radiations emanating from the
sun or other source and many ways of carrying
out the same will at once suggest themselves
from the above description. By way of illustra-
tion a modified arrangement is shown in Fig. 200
2, in which the source S of radiant energy is
a special form of Roentgen tube devised by
me having but one terminal k, generally of
aluminium, in the form of half a sphere with
a plain polished surface on the front side, from 205
which the streams are thrown off. It may be
excited by attaching it to one of the terminals
of any generator of sufficiently-high electro-
motive force; but whatever apparatus be used
it is important that the tube be exhausted to 210
a high degree, as otherwise it might prove en-
tirely ineffective. The working or discharge
circuit connected to the terminals T T' of the

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No. 685,957

Patented Nov. 5, 1901.

N. TESLA

APPARATUS FOR THE UTILIZATION OF RADIANT ENERGY

Application filed Mar. 23, 1901.

(No Model.)

Fig 1

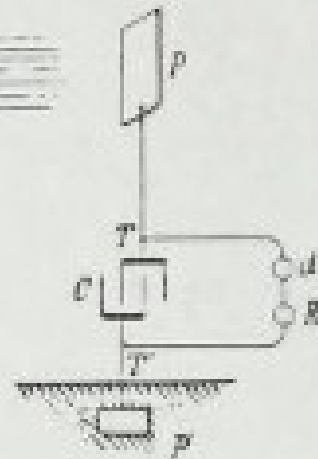


Fig 2

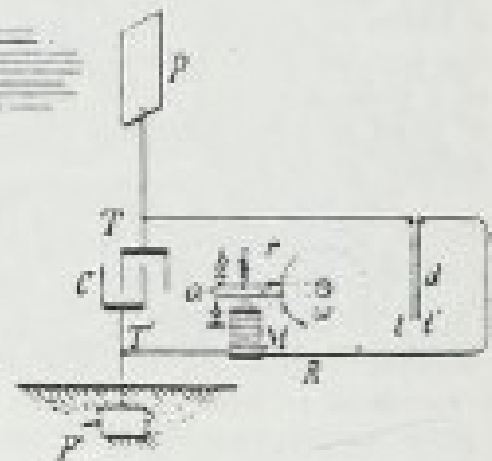
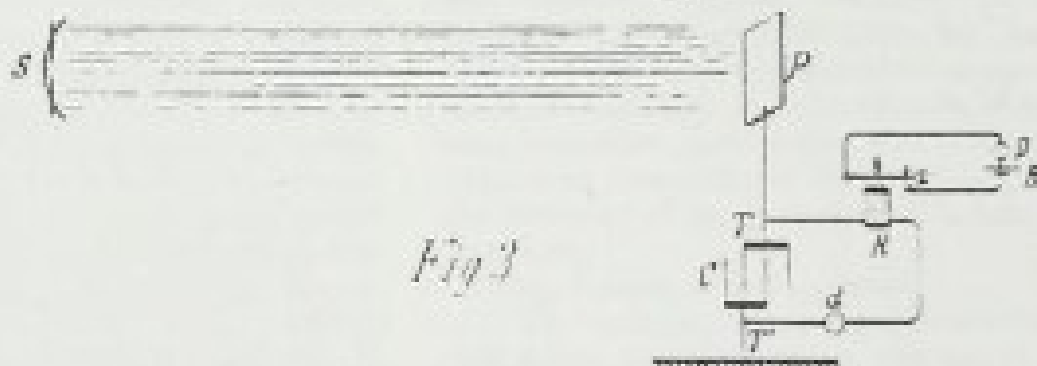


Fig 3



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NIKOLA TESLA, OF NEW YORK, N. Y.

APPARATUS FOR THE UTILIZATION OF RADIANT ENERGY.

SPECIFICATION forming part of Letters Patent No. 685,957, dated November 5, 1901.
Application filed March 21, 1901. Serial No. 52,155. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at the borough of Manhattan, in the city, county, and State of New York, have invented certain new and useful Improvements in Apparatus for the Utilization of Radiant Energy, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

It is well known that certain radiations—such as those of ultra-violet light, cathodic, Roentgen rays, or the like—possess the property of charging and discharging conductors of electricity, the discharge being particularly noticeable when the conductor upon which the rays impinge is negatively electrified. These radiations are generally considered to be either vibrations of extremely small wave lengths, and in explanation of the phenomena noted it has been assumed by some authorities, that they ionize or render conducting the atmosphere through which they are propagated. My own experiments and observations, however, lead me to conclusions more in accord with the theory heretofore advanced by me that sources of such radiant energy throw off with great velocity minute particles of matter which are strongly electrified, and therefore capable of charging an electrical conductor, or, even if not so, may at any rate discharge an electrified conductor either by carrying off bodily its

of mechanical or electrical devices or rendered useful in many other ways.

In applying my discovery I provide a condenser, preferably of considerable electrostatic capacity, and connect one of its terminals to an insulated metal plate or other conducting-body exposed to the rays or streams of radiant matter. It is very important, particularly in view of the fact that electrical energy is generally supplied at a very slow rate to the condenser, to construct the same with the greatest care. I use, by preference, the best quality of mica as dielectric, taking every possible precaution in insulating the armatures, so that the instrument may withstand great electrical pressures without leaking and may leave no perceptible electrification when discharging instantaneously. In practice I have found that the best results are obtained with condensers treated in the manner described in a patent granted to me February 23, 1897, No. 577,671. Obviously the above precautions should be the more rigorously observed the slower the rate of charging and the smaller the time interval during which the energy is allowed to accumulate in the condenser. The insulated plate or conducting-body should present as large a surface as practicable to the rays or streams of matter, I having ascertained that the amount of energy conveyed to it per unit of time is under otherwise identical conditions proportionate to the area exposed, or

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No. 655,838.

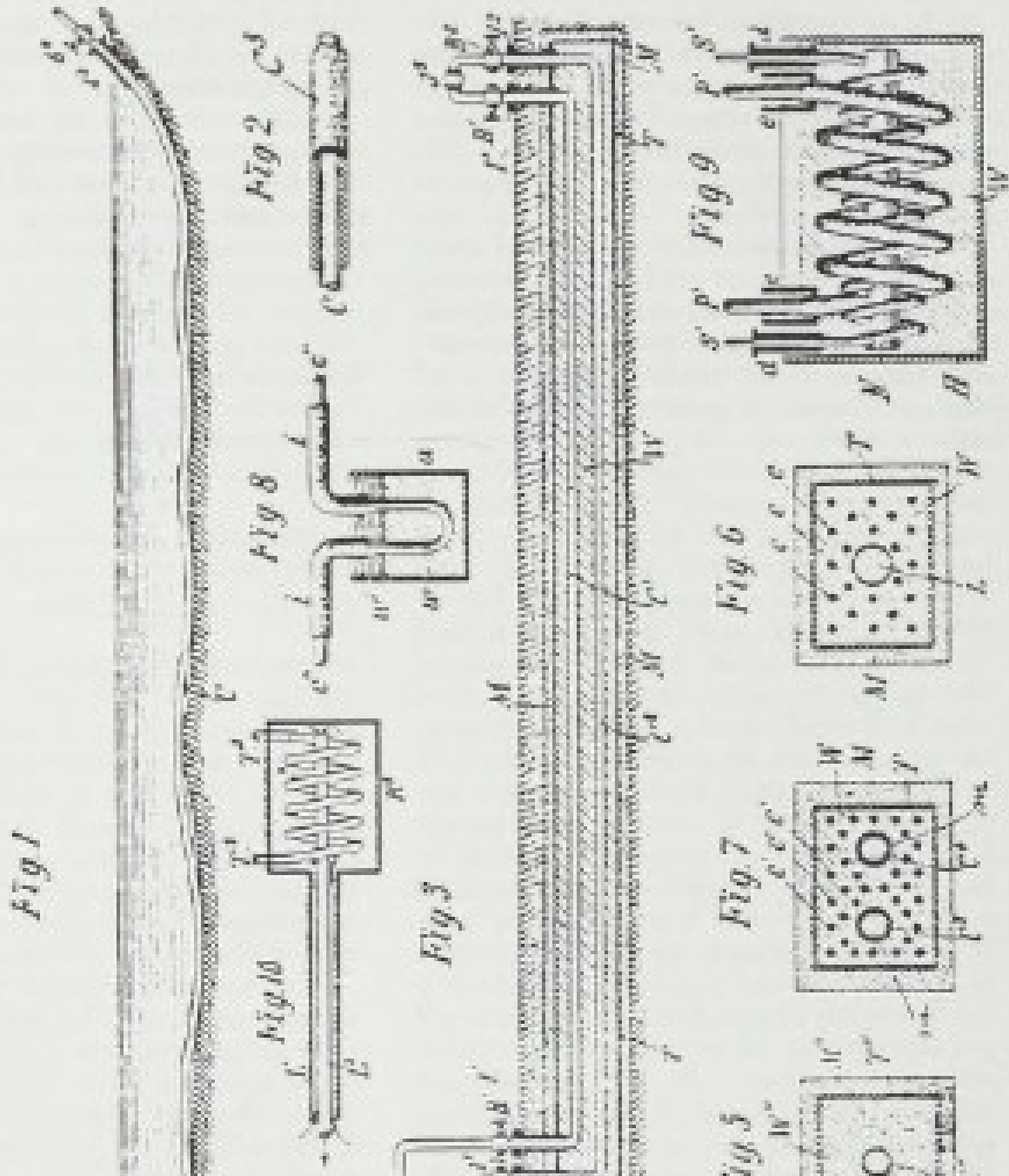
Patented Aug. 14, 1900.

H. TESLA.

METHOD OF INSULATING ELECTRIC CONDUCTORS.

(Application filed June 18, 1900.)

(No Model.)



THE COMPLETE PATENTS OF NIKOLA TESLA

UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y.

METHOD OF INSULATING ELECTRIC CONDUCTORS.

SPECIFICATION forming part of Letters Patent No. 655,838, dated August 14, 1900.
Application filed June 15, 1900. Serial No. 20,405. (No specimen.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing in the borough of Manhattan, in the city, county, and State of New York, have invented certain new and useful Improvements in Methods of Insulating Electric Conductors, of which the following is a specification, reference being had to the accompanying drawings.

It has long been known that many substances which are more or less conducting when in the fluid condition become insulators when solidified. Thus water, which is in a measure conducting, acquires insulating properties when converted into ice. The existing information on this subject, however, has been heretofore of a general nature only and chiefly derived from the original observations of Faraday, who estimated that the substances upon which he experimented, such as water and aqueous solutions, insulate an electrically-charged conductor about one hundred times better when rendered solid by freezing, and no attempt has been made to improve the quality of the insulation obtained by this means or to practically utilize it for such purposes as are contemplated in my present invention. In the course of my own investigations, more especially those of the electric properties of ice, I have discovered some novel and important facts, of which the more prominent are the following: first, that under certain conditions, when the leakage of the electric charge ordinarily taking place is rigor-

tions have led me to the invention of a novel method of insulating conductors, rendered practicable by reason of the above facts and advantageous in the utilization of electrical energy for industrial and commercial purposes. Broadly stated, the method consists in insulating an electric conductor by freezing or solidifying and maintaining in such state, by the circulation of a cooling agent, the material surrounding or contiguous to the conductor.

In the practical carrying out of my method I may employ a hollow conductor and pass the cooling agent through the same, thus freezing the water or other medium in contact with or close to such conductor, or I may use expressly for the circulation of the cooling agent an independent channel and freeze or solidify the adjacent substance, in which any number of conductors may be embedded. The conductors may be bare or covered with some material which is capable of keeping them insulated when it is frozen or solidified. The frozen mass may be in direct touch with the surrounding medium or it may be in a degree protected from contact with the same by an inclosure more or less impervious to heat. The cooling agent may be any kind of liquid, preferably of low freezing-point, as brine, or it may be a gas, as atmospheric air, oxygen, carbonic acid, ammonia, illuminating-gas, or hydrogen. It may be forced through the channel by gravity, pressure, or suction, produced mechanically or otherwise, or by any other kind of force. It may be continually renewed or

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object is sought, but offers exceptional advantages in those instances in which the freely-oscillating discharges of a condenser are utilized.

The best and most convenient manner of carrying out the invention of which I am now aware is to surround the freely-vibrating circuit or conductor, which is to be maintained at a low temperature, with a suitable cooling medium, which may be any kind of freezing mixture or agent, such as liquid air, and in order to derive the fullest benefit from the improvement the circuit should be primarily constructed so as to have the greatest possible self-induction and the smallest practicable resistance, and other rules of construction which are now recognized should be observed. For example, when in a system of transmission of energy for any purpose through the natural media the transmitting and receiving conductors are connected to earth and to an insulated terminal, respectively, the lengths of these conductors should be one-quarter of the wave length of the disturbance propagated through them.

In the accompanying drawing I have shown graphically a disposition of apparatus which may be used in applying practically my invention.

The drawing illustrates in perspective two devices, either of which may be the transmitter, while the other is the receiver. In each there is a coil of few turns and low resistance, (designated in one by A and in the other by A'.) The former coil, supposed to be forming part of the transmitter, is to be connected with a suitable source of current, while the latter is to be included in circuit with a receiving device. In inductive relation to said coils in each instrument is a flat spirally-wound coil B or B', one terminal of which is shown as connected to a ground-plate C, while the other, leading from the center, is adapted to be connected to an insulated terminal, which is generally maintained at an elevation in the air. The coils B B' are placed in insulating-receptacles D, which contain the freezing agent and around which the coils A and A' are wound.

Coils in the form of a flat spiral, such as those described, are eminently suited for the production of free oscillations; but obviously

and the inductance of circuit B and inversely to the resistance of the latter. Other conditions remaining the same, the intensity of the oscillations in the resonating-circuit B will be increased in the same proportion as its resistance is reduced. Very often, however, the conditions may be such that the gain sought is not realized directly by diminishing the resistance of the circuit. In such cases the skilled expert who applies the invention will turn to advantage the reduction of resistance by using a correspondingly longer conductor, thus securing a much greater self-induction, and under all circumstances he will determine the dimensions of the circuit, so as to get the greatest value of the ratio of its inductance to its resistance, which determines the intensity of the free oscillations. The vibrations of coil B, greatly strengthened, spread to a distance and on reaching the tuned receiving-conductor B' excite corresponding oscillations in the same, which for similar reasons are intensified, with the result of inducing correspondingly stronger currents or oscillations in circuit A, including the receiving device. When, as may be the case in the transmission of intelligible signals, the circuit A is periodically closed and opened, the effect upon the receiver is heightened in the manner above described not only because the impulses in the coils B and B' are strengthened, but also on account of their persistence through a longer interval of time. The advantages offered by the invention are still more fully realized when the circuit A of the transmitter instead of having impulses of an arbitrary frequency impressed upon it is itself permitted to vibrate at its own rate, and more particularly so if it be energized by the freely-oscillating high-frequency discharges of a condenser. In such a case the cooling of the conductor A, which may be effected in any suitable manner, results in an extraordinary magnification of the oscillation in the resonating-circuit B, which I attribute to the increased intensity as well as greater number of the high-frequency oscillations obtained in the circuit A. The receiving-coil B' is energized stronger in proportion and induces currents of greater intensity in the circuit A'. It is evident from the above that the greater the number of the freely-vibrating circuits which alternately receive and transmit energy from one to another

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mission of signals and to exclude much more
230 effectively interference with the same than has
been possible heretofore.

Having now described my invention, what
I claim is—

1. The combination with a circuit adapted
235 to vibrate freely, of means for artificially cool-
ing the same to a low temperature, as herein
set forth.

2. In an apparatus for transmitting or re-
ceiving electrical impulses or oscillations, the
240 combination with a primary and a secondary
circuit, adapted to vibrate freely in response
to the impressed oscillations, of means for
artificially cooling the same to a low tempera-
ture, as herein set forth.

245 3. In a system for the transmission of elec-
trical energy, a circuit upon which electrical
oscillations are impressed, and which is adapted
to vibrate freely, in combination with a recep-
tacle containing an artificial refrigerant in
250 which said circuit is immersed, as herein set
forth.

4. The means of increasing the intensity of
the electrical impulses or oscillations impressed
upon a freely-vibrating circuit, consisting of
an artificial refrigerant combined with and ap- 255
plied to such circuit and adapted to maintain
the same at a low temperature.

5. The means of intensifying and pro-
longing the electrical oscillations produced in
a freely-vibrating circuit, consisting of an arti- 260
ficial refrigerant applied to such circuit and
adapted to maintain the same at a uniformly-
low temperature.

6. In a system for the transmission of en-
ergy, a series of transmitting and receiving cir- 265
cuits adapted to vibrate freely, in combination
with means for artificially maintaining the
same at a low temperature, as set forth.

NIKOLA TESLA.

Witnesses:

JOHN C. KERR,

M. LAWSON DYER.

THE COMPLETE PATENTS OF NIKOLA TESLA

No. 685,012.

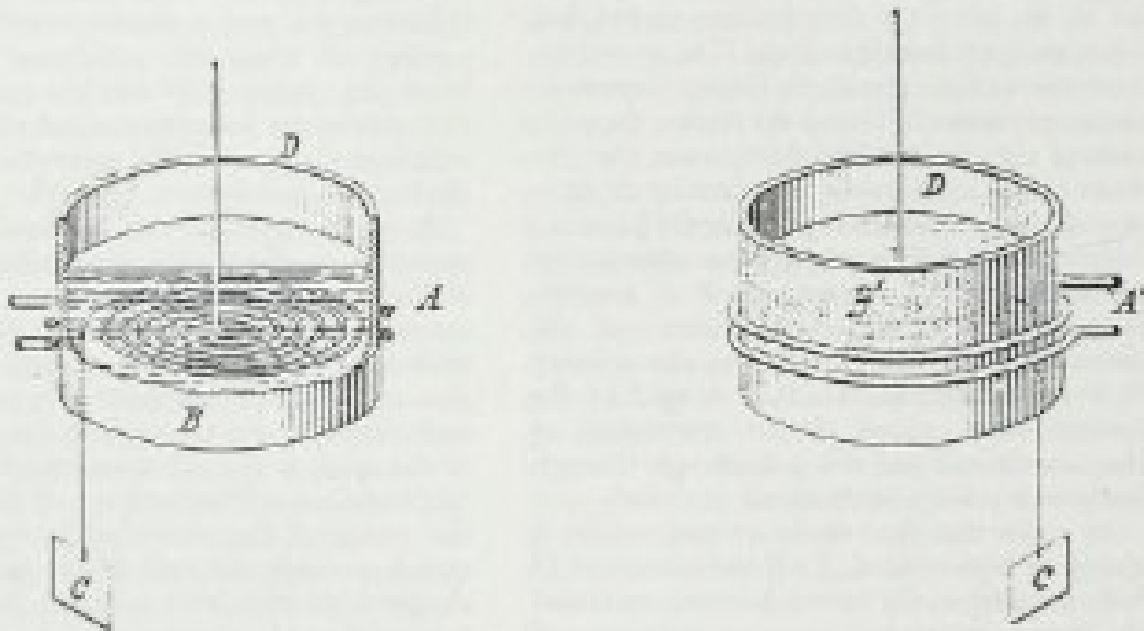
Patented Oct. 22, 1901.

N. TESLA.

MEANS FOR INCREASING THE INTENSITY OF ELECTRICAL OSCILLATIONS.

(Application filed Mar. 21, 1900. Renewed July 3, 1901.)

(No Model.)



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UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y.

MEANS FOR INCREASING THE INTENSITY OF ELECTRICAL OSCILLATIONS.

SPECIFICATION forming part of Letters Patent No. 685,012, dated October 22, 1901.

Application filed March 21, 1900; Renewed July 3, 1901. Serial No. 66,980. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at the borough of Manhattan, in the city, county, and State of New York, have invented certain new and useful Improvements in Means of Increasing the Intensity of Electrical Oscillations, of which the following is a specification, reference being had to the drawings accompanying and forming part of the same.

In many scientific and practical uses of electrical impulses or oscillations—as, for example, in systems of transmitting intelligence to distant points—it is of great importance to intensify as much as possible the current impulses or vibrations which are produced in the circuits of the transmitting and receiving instruments, particularly of the latter.

It is well known that when electrical impulses are impressed upon a circuit adapted to oscillate freely the intensity of the oscillations developed in the same is dependent on the magnitude of its physical constants and the relation of the periods of the impressed and of the free oscillations. For the attainment of the best result it is necessary that the periods of the impressed should be the same as that of the free oscillations, under which conditions the intensity of the latter is greatest and chiefly dependent on the inductance and resistance of the circuit, being directly proportionate to the former and inversely to the latter. In order, therefore, to intensify the impulses or oscillations excited in the circuit—in other words,

of the section of the conductor with the object of reducing its resistance is, beyond a certain limit, of little or no value, principally because electrical oscillations, particularly those of high frequency, pass mainly through the superficial conducting layers, and while it is true that this drawback may be overcome in a measure by the employment of thin ribbons, tubes, or stranded cables, yet in practice other disadvantages arise, which often more than offset the gain.

It is a well-established fact that as the temperature of a metallic conductor rises its electrical resistance increases, and in recognition of this constructors of commercial electrical apparatus have heretofore resorted to many expedients for preventing the coils and other parts of the same from becoming heated when in use, but merely with a view to economizing energy and reducing the cost of construction and operation of the apparatus.

Now I have discovered that when a circuit adapted to vibrate freely is maintained at a low temperature the oscillations excited in the same are to an extraordinary degree magnified and prolonged, and I am thus enabled to produce many valuable results which have heretofore been wholly impracticable.

Briefly stated, then, my invention consists in producing a great increase in the intensity and duration of the oscillations excited in a freely-vibrating or resonating circuit by maintaining the same at a low temperature.

Ordinarily in commercial apparatus such provision is made only with the object of reducing the

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UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y.

ELECTRICAL IGNITER FOR GAS-ENGINES.

SPECIFICATION forming part of Letters Patent No. 609,250, dated August 16, 1898.

Application filed February 17, 1897. Renewed June 15, 1898. Serial No. 681,524. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electrical Igniters for Gas-Engines and Analogous Purposes, of which the following is a specification, reference being had to the drawing accompanying and forming a part of the same.

In certain kinds of apparatus it is necessary for the operation of the machine itself or for effecting the object for which it is used to produce an electric spark or any other similar local effect at a given instant of time or at predetermined intervals. For example, in certain gas or explosive engines a flame or spark is necessary for the ignition of an explosive mixture of air and gas under the piston, and the most effective way of igniting the gaseous mixture has been found to be the production in the cylinder at the proper moments of an electric spark. The only practicable device by which this has been accomplished heretofore is an induction-coil comprising a primary and secondary circuit with a buzzer or rapidly-acting automatic circuit-breaker in the primary and a circuit-controller, such as a switch or commutator, located also in the primary or battery circuit and operated by some moving portion of the apparatus to temporarily close such circuit at the proper time, and thereby set in operation the automatic circuit-breaker,

There is, however, no form of vibrating or quick-acting circuit-breaker of which I am aware that can be depended upon to operate with certainty to produce such a spark or which will continue to operate for any length of time without deterioration, and hence not only in the case of engines of the kind described, but in other forms of apparatus which involve the use of a high-tension induction-coil with a quick-acting circuit-breaker, the operation of the machine is contingent upon the proper operation of a comparatively insignificant but essential part.

The object of my invention is to provide a more certain and satisfactory means for use with and control by such machines or apparatus as I have mentioned for producing sparks or discharges of the desired character, and to this end I employ the following arrangement: Any suitable moving portion of the apparatus is caused to mechanically control the charging of a condenser and its discharge through a circuit in inductive relation to a secondary circuit leading to the terminals between which the discharge is to occur, so that at the desired intervals the condenser may be discharged through its circuit and induce in the other circuit a current of high potential which produces the desired spark or discharge.

One practical means of accomplishing this is to employ any proper form of switch or commutator operated directly or through suit-

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by the closing of the switch a strong secondary discharge induced by the discharge of the condenser through the primary will occur. It is possible by this means not only to produce a strong discharge of high tension, as in the form of a spark well adapted for the ignition of gas or other purposes for which sparks are employed, but to secure such result by apparatus very much less complicated and expensive than that heretofore employed for the purpose and which will be capable of certain and effective operation for an indefinite period of time.

I have illustrated the principle of my improvement and the manner in which the same is or may be carried out in the drawing hereto annexed. The invention is shown as used for effecting the operation of the piston of a gas-engine, the figure being a diagram.

A designates the cylinder of a gas-engine, B the piston, and C the piston-rod. Other parts of the engine are omitted from the illustration as unnecessary to an understanding of the invention.

On the piston-rod C is a commutator or circuit-controller upon which bear the terminals *a* *b* of an electric circuit D. This commutator comprises a continuous ring *c* and a split ring *d* side by side, so that when the terminals are on the latter the circuit is interrupted, but when on the former it is closed. The to-and-fro movement of the piston, therefore, operates to alternately make and break the circuit, the position of the commutator being such that the make occurs at the moment desired for the ignition of the explosive charge under the piston.

In the circuit D is a battery or other source of current E and the primary F of a transformer. Across the two conductors of the circuit, between the battery and the primary F, is a condenser G, which is charged by the battery when circuit D is interrupted at the commutator and which discharges through the primary when such circuit is closed.

In order that the condenser may receive a charge of high tension, a self-induction coil H is introduced in the circuit between itself and the battery, which coil stores up the energy of the battery when the circuit D is closed at the commutator and discharges it into the con-

employed in carrying out my improvement and that these may be varied within wide limits.

What I claim is—

1. In an apparatus which depends for its operation or effect upon the production of a sudden electric discharge at a given instant, or at predetermined intervals of time, the combination with a moving part of said apparatus of a switch or commutator, a condenser, a charging-circuit for the same, a primary circuit through which the condenser discharges, and a secondary circuit in inductive relation to the said primary circuit and connected with the terminals at the point in the apparatus where the discharge is required, the switch or commutator being operated by the said moving part to effect the discharge of the condenser at the proper intervals, as set forth.

2. In an apparatus which depends for its operation or effect upon the production of a sudden electric discharge at a given instant, or at predetermined intervals of time, the combination with a moving part of said apparatus of a circuit and a circuit-controller adapted to close said circuit at the time when the occurrence of said discharge is desired, a source of current in said circuit, a condenser adapted to be charged by said source while the circuit is interrupted, and a transformer through the primary of which the condenser discharges when the circuit is closed, the secondary of the transformer being connected with the terminals at the point in the apparatus where the discharge is required, as set forth.

3. In an apparatus which depends for its operation or effect upon the production of an electric discharge, at a given instant, or at predetermined intervals of time, the combination with a moving part of said apparatus of a circuit and a circuit-controller adapted to close said circuit at the time when the occurrence of the spark is desired, a source of current in said circuit, a self-induction coil which stores the energy of the source while the circuit is closed, a condenser into which said coil discharges when the circuit is broken, and a transformer through the primary of which the condenser discharges, the secondary of said transformer being connected with separated terminals

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as well as the capacity of the condenser itself,
100 may be given practically any desired value the
frequency of the discharge-current may be ad-
justed at will. The potential of the high-
frequency discharge-current is raised by a sec-
ondary coil N in inductive relation to the pri-
105 mary M. The conductors of such secondary
circuit are connected to two insulated
conducting-plates P P, and when the appara-
tus is in operation a discharge in the form of
streams will be maintained between such
110 plates, as indicated by the wavy lines in the
figures. If air be forced between the plates P
during this discharge, the effectiveness of the
apparatus is increased and ozone is generated
in large quantities. In order to secure this re-
115 sult, I inclose the said plates P P in a casing
R of any proper description, through which a
current of air is maintained by a fan S,
mounted on the shaft of the motor.

This apparatus may be constructed and
120 combined in very compact form and small
compass. Its operation involves but a small
expenditure of energy, while it requires practi-
cally no care or attention for the continued
production of ozone in unlimited amount.

125 What I claim as my invention is—

1. The combination with a circuit of direct
currents, of a controller for making and break-
ing the same, a motor included in or con-
nected with said circuit so as to increase its
130 self-induction, and driving the said controller,
a condenser in a circuit around the controller,
and a transformer through the primary of
which the condenser discharges, as set forth.

2. The combination with a circuit of direct
135 currents, of a controller for making and break-
ing the same, a series-wound motor having its
coils included in said circuit and driving the
said controller, a condenser connected with
the circuit around the point of interruption
140 therein, and a transformer, the primary of
which is in the discharge-circuit of the con-
denser, as set forth.

3. A device for producing ozone comprising
145 in combination, surfaces between which an
electrical discharge takes place, a transformer

for producing the potential necessary for such
discharge, a condenser in the primary circuit
of the transformer, a charging circuit, means
for charging the condenser by such circuit and
discharging it through the primary of the 150
transformer, and a device for maintaining a
current of air between the discharge-surfaces,
as set forth.

4. A device for producing ozone comprising
in combination, surfaces between which an 155
electrical discharge takes place, a transformer
for producing the potential necessary for such
discharge, a condenser in the primary circuit
of the transformer, a charging-circuit, means
for charging the condenser by such circuit and 160
discharging it through the primary of the
transformer, a motor operated by the charging-
circuit, and a device operated thereby for
maintaining a current of air between the
discharge-surfaces, as set forth. 165

5. A device for producing ozone comprising
in combination, surfaces between which an
electrical discharge takes place, a transformer
for producing the potential necessary for such
discharge, a condenser in the primary circuit of 170
the transformer, a charging-circuit, a circuit-
controller effecting the charging and discharg-
ing of the condenser, and a fan-motor con-
nected with the charging-circuit and operating
the circuit-controller and adapted to maintain 175
a current of air between the discharge-surfaces,
as set forth.

6. A device for producing ozone comprising
in combination, means for charging a con-
denser, a circuit of low self-induction and re- 180
sistance into which the condenser discharges,
a coil for raising the potential of such dis-
charge, and means for passing a current of air
through the high-potential discharge, as set
forth. 185

NIKOLA TESLA.

Witnesses

DRURY W. COOPER,
M. LAWSON DYER.

THE COMPLETE PATENTS OF NIKOLA TESLA

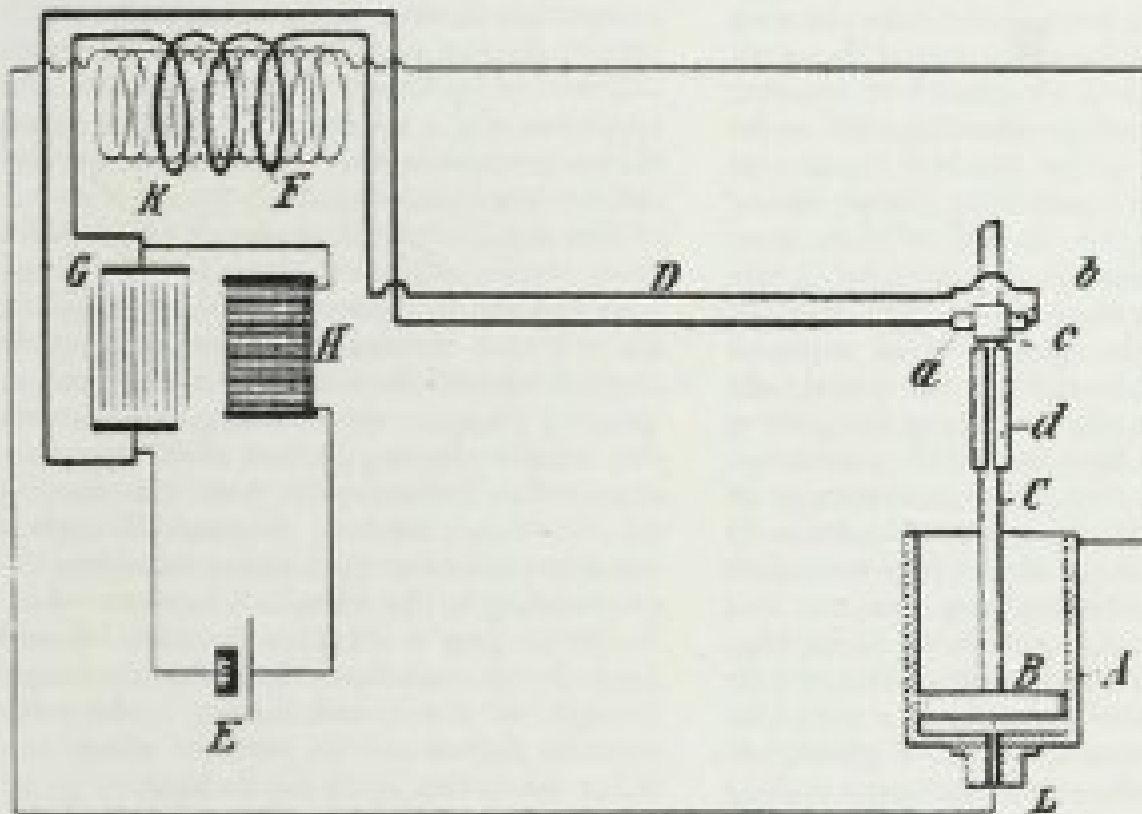
No. 609,250.

Patented Aug. 16, 1898.

N. TESLA.

ELECTRICAL IGNITER FOR GAS ENGINES.

(No Model.)



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(No Model.)

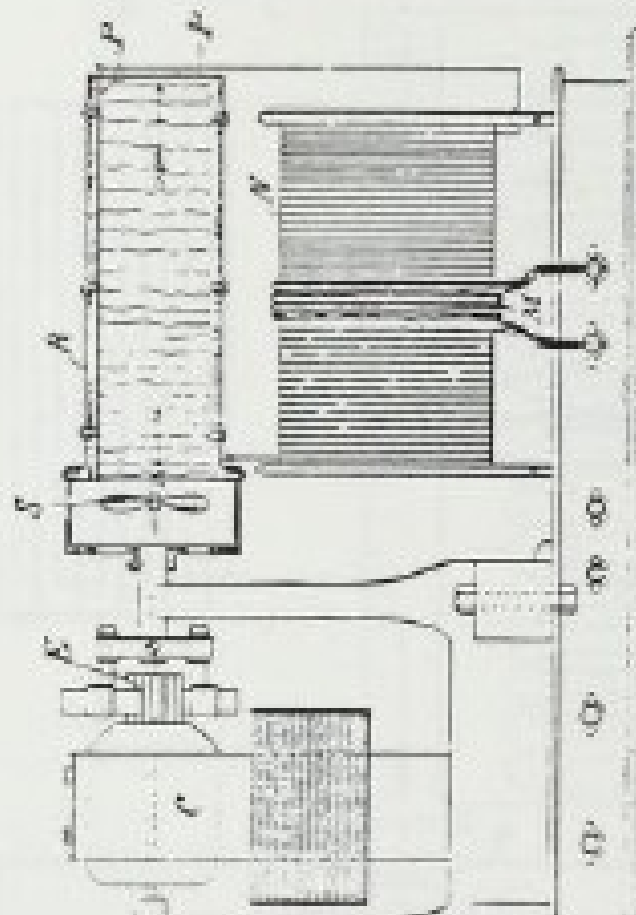
2 Sheets—Sheet 2

N. TESLA. APPARATUS FOR PRODUCING OZONE.

No. 568,177.

Patented Sept. 22, 1896.

Fig. 2



THE COMPLETE PATENTS OF NIKOLA TESLA

UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y.

APPARATUS FOR PRODUCING OZONE.

SPECIFICATION forming part of Letters Patent No. 568,177, dated September 22, 1896.
Application filed June 17, 1896. Serial No. 595,827. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Apparatus for Producing Ozone, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

The invention subject of my present application has primarily as its object to provide a simple, cheap, and effective apparatus for the production of ozone or such gases as are obtained by the action of high-tension electrical discharges, although in the application to such purposes of the apparatus heretofore invented by me and designed for the production of electric currents of high frequency and potential I have made certain improvements in such apparatus itself which are novel and useful in other and more general applications of the same. I have heretofore shown and described, notably in Patents No. 462,418, dated November 3, 1891, and No. 454,622, dated June 23, 1891, an apparatus devised for the purpose of converting and supplying electrical energy in a form suited for the production of certain novel electrical phenomena which require currents of higher frequency and potential than can readily or even possibly be developed by generators of the ordinary types or by such mechanical appliances as were theretofore known. This apparatus involved means for utilizing the intermittent or oscillation discharges

cient to describe its operation and effects when used for the purpose of generating ozone.

In the accompanying drawings, illustrative of the principle of construction and mode of operation of my improvement, Figure 1 is a diagrammatic illustration of the invention; and Fig. 2, a view, partly, in side elevation and partly in section, of the apparatus as I construct it for practical use.

The device hereinafter described is especially designed for direct application to and use with existing circuits carrying direct currents, such as the ordinary municipal incandescent-lighting circuits.

Let A B designate the terminals from any given circuit of this character. In such circuit I connect up an electromagnetic motor C in any of the usual ways. That is to say, the coils of the field and armature may be in series or derivation or wholly independent, and either or both are connected up in the circuit. In the present instance one terminal, as B, is connected to one of the binding-posts, from which the circuit is led through one field-coil, D, the brushes and commutator E, the other field-coil, F, and thence to a brush G, which rests upon a circuit-controller H, consisting in general of a conducting disk or cylinder with insulating-sections in its periphery. The other terminal, as A, connects with a second brush K, bearing on the controller, so that the current which passes through and operates the motor is periodically interrupted. For this reason the iron core of the motor should be

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(No Model.)

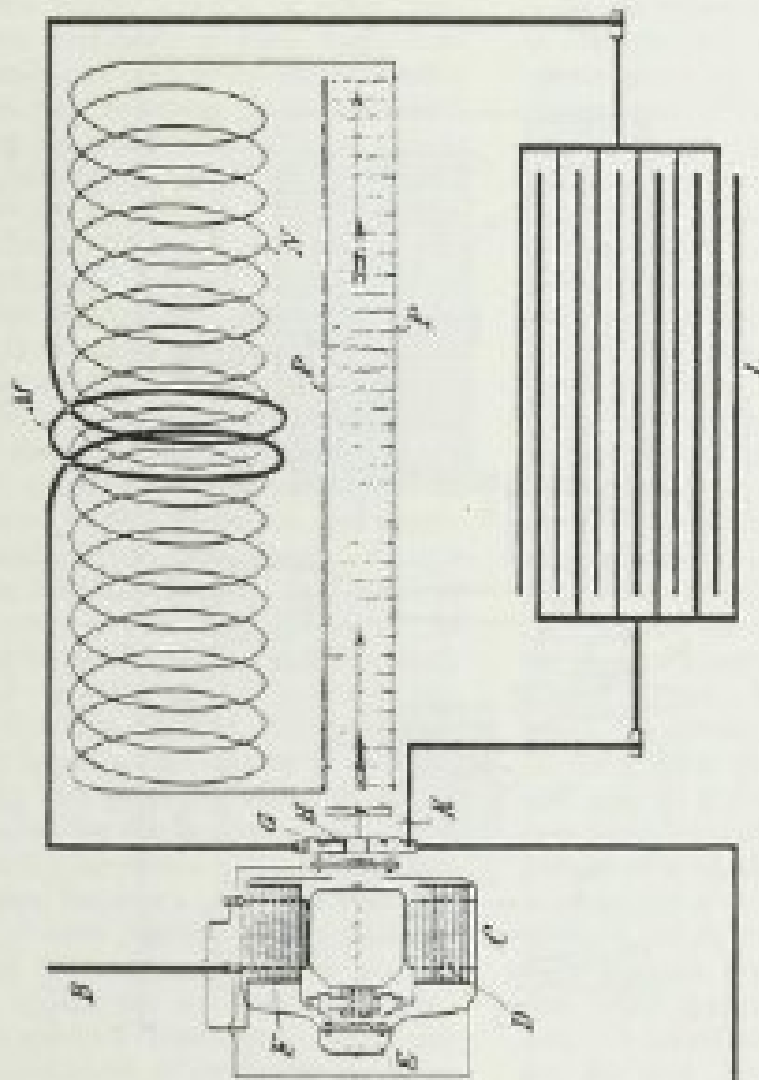
2 Sheets—Sheet 1.

N. TESLA. APPARATUS FOR PRODUCING OZONE.

No. 568,177.

Patented Sept. 22, 1896.

Fig. 1



THE COMPLETE PATENTS OF NIKOLA

TESLA

augmented by merely manipulating block 13 or valve 16 as described.

Whenever it is desired to descend vertically, the aviator will reverse the operations as applying to substantial vertical ascent, which is to say, bring the machine gradually into starting attitude, at the same time increasing the supply of fluid to the motors and the vertical component of the propeller thrust, while reducing the horizontal. Finally, he will steadily reduce the fluid supply and the vertical thrust so as to descend to the landing place at a very low, safe velocity.

In the preceding I have described a flying machine characterized by a number of novel constructive and operative features and well suited for meeting a pressing necessity in the present state of the art. The chief improvements consist in first, adapting my turbine motor for excessive overload without appreciable increase of its weight, second, providing large variable inlet ports and corresponding exhaust openings, with the object of meeting the abnormal power requirements in the starting, landing and other short operations, and still preserving a high efficiency in horizontal flight; third, combining with the turbine in a fluid pressure generator of adequate capacity with means for control and, fourth, embodying these and other features in a suitable structure improved in various details. These may be greatly varied and I wish it to be understood that I do not limit myself to the precise arrangements illustrated and described.

I claim as my invention:

1. In an aeroplane adapted for vertical and horizontal propulsion and change from one to the other attitude, the combination of means for tilting the machine in the air, a fluid pressure generator of a capacity several times greater than normally required in horizontal flight, a motor capable of carrying overloads adequate for support in all attitudes, and means for controlling the supply of the fluid to the motor in accordance with the inclination of the machine.

2. In an aeroplane adapted for vertical and horizontal propulsion and change from one to the other attitude, the combination with means for tilting the machine in the air and

allel to the principal axis of the same and including a fluid pressure generator having a capacity several times greater than normally required in horizontal flight, a motor capable of carrying over-loads adequate for support in all attitudes, and means for controlling the supply of the fluid to the motor in accordance with the inclination of the machine.

3. In an aeroplane adapted for vertical and horizontal propulsion and change from one to the other attitude, the combination of means for tilting the machine in the air, a fluid pressure generator capable of supplying fluid at a rate several times greater than required for a horizontal flight, a prime mover consisting of a rotor of plane spaced discs with central openings and an enclosing casing with inlet and outlet orifices of a section much greater than required for normal performances respectively at the periphery and center of the same, and means for controlling the supply of the fluid to the motor in accordance with the inclination of the machine.

4. In an aeroplane adapted for vertical and horizontal propulsion and change from one to the other attitude, the combination of means for tilting the machine in the air, a thrust producing system having its principal energy producing elements designed for normal load in horizontal flight but capable of carrying over-loads adequate for support of the aeroplane in all attitudes, and means for controlling the energy produced in said system in accordance with the inclination of the machine.

5. In a flying machine of the kind described in combination with means for vertical and lateral control of two wheel bases at right angles to one another as set forth.

6. In a flying machine of the kind described in combination with means for vertical and lateral control of two wheel bases at right angles to one another and having one or more wheels common to both.

In testimony whereof I hereunto affix my signature.

NIKOLA TESLA.

THE COMPLETE PATENTS OF NIKOLA TESLA

CERTIFICATE OF CORRECTION.

Patent No. 1,655,114.

Granted January 3, 1928.

NIKOLA TESLA.

It is hereby certified that error appears in the printed specification of the above-numbered patent requiring correction as follows: Page 1, after line 54, strike out the formula and insert instead

$$E = \Sigma \left(\frac{1}{mr^2} \right);$$

and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 20th day of March, A. D. 1928.

[SEAL]

M. J. MOORE,

Acting Commissioner of Patents.

THE COMPLETE PATENTS OF NIKOLA TESLA

true no matter how much its resistance is reduced.

Another very serious defect of this kind of
110 flying machine, from the practical point of view, is found in its inability of supporting itself in the air in case of failure of the motor, the projected area of the propeller blades being inadequate for reducing the
215 speed of the fall sufficiently to avoid disaster, and this is an almost fatal impediment to its commercial use.

From the preceding facts, which are ignored in the technical publications on the subject, it
220 will be clear that the successful solution of the problem is in a different direction.

In an application of even date, referred to above, I have disclosed an invention which meets the present necessity in a simple manner and, briefly stated, consists in a novel method
225 of transporting bodies through the air according to which the machine is raised and lowered solely by the propeller and sustained in lateral flight by planes.

230 My present application is based on new and useful features and combinations of apparatus which I have devised for carrying this method into practice.

Full knowledge of these improvements will
235 be readily gained by reference to the accompanying drawings in which

Fig. 1 illustrates the machine in the starting or landing position and

Fig. 2 in horizontal flight;

240 Fig. 3 is a plan view of the same with the upper plane partly broken away and

Fig. 4 and Fig. 5 sectional views of constructive details.

The structure is composed of two planes or
245 foils 1, 1 rigidly joined. Their length and distance apart may be such as to form a near-square for the sake of smallness and compactness. With the same object the tail is omitted or, if used, it is retractable. In order to raise
250 the machine vertically a very light and powerful prime mover is necessary and as particularly suited for the purpose, I employ, preferably, a turbine described in my U. S. Patent 1,061,206 of May 6, 1913, which not only
255 fulfills these requirements but lends itself especially to operation at very high temperatures.

turbines rotating in the same direction and neutralizing the gyroscopic moment of the screw. If, instead of one, two propellers are used, either coaxially or otherwise disposed, 275 the motors should revolve in opposite directions. The seats 4, 4 for the operator and passengers are suspended on trunnions 5, 5 on which they can turn through an angle of about 90 degrees, springs and cushions (not shown) 280 being employed to insure and limit their motion through this angle. The ordinary devices for lateral and directional control 6, 6, 7, 7 and 8, 8 are provided with mechanical connections enabling the aviator to actuate them 285 by hand or foot from his seat in any position.

Stated in a few words, the operation is as follows: At the start, sufficient power is turned on by suitable means, also within reach, and the machine rises vertically in the air to the 290 desired height when it is gradually tilted through manipulation of the elevator devices and then proceeds more and more like an aeroplane, the sustaining force of the propeller being replaced by vertical reaction of the foils 295 as the angle of inclination diminishes and horizontal velocity increases. In descending, the forward speed is reduced and the machine righted again, acting as a helicopter with the propeller supporting all the load. The turbine 300 used is of great lightness and activity exceptionally qualified to perform such work for which the present aviation motors are unsuited. It is capable of carrying an extraordinarily great overload and running at excessive speed, and 305 during the starting, landing and other relatively short operations, not only can the necessary power be easily developed, but this can be accomplished without incurring a serious loss of efficiency. Owing to its extreme sim- 310 plicity the motive apparatus is very reliable, but should the power give out accidentally, landing can still be effected by volplaning. For this purpose, in addition to wheels 9, 9 and 10, 10, wheels 11, 11 are employed, the latter 315 being mounted on the forward end under the lower plane and so that when the machine rests on level ground, the propeller shaft will have the desired inclination which is deemed best for rising in the manner of an aeroplane. 320 Such a "helicopter-plane," constructed and

THE COMPLETE PATENTS OF NIKOLA TESLA

small importance. Instead of a single large propeller, as described, a number of small ones can be used, when the turbine units may be
340 connected advantageously in stages and the gearing dispensed with. The biplane seems to be particularly well suited for the chief purpose contemplated, but the invention is equally well applicable to monoplanes and other types.

345 In order to secure the best results I have found it indispensable to depart, in some respects, from the usual design of my turbines and embody in them certain constructive features and means for varying the power developed from the minimum necessary in
350 horizontal flight to an amount exceeding by far their rated performance, as may be required in the operations of ascent and descent, or spurts of speed, or in combatting the fury
355 of the elements. Furthermore, I so proportion and coordinate the fluid pressure generator supplying the primary energy, the propelling and the controlling means, that for any attitude or working condition of the machine the
360 requisite thrust may be almost instantly produced and accurately adjusted.

The understanding of these improvements will be facilitated by reference to Fig. 4 and Fig. 5. In the first named the turbines are
365 intended to operate as rotary engines, expanding the gases in the rotor as well as the inlet nozzle or port 12, the depth of which can be varied by shifting a block 13, fitting freely in a milled channel of the casing,
370 through the medium of lever 14 controlled by the aviator. The orifice for the passage of the elastic fluid is straight or slightly converging, so that a much smaller velocity is obtained than with an expanding nozzle, this enabling
375 the best relation between the peripheral speed of the rotor and that of the fluid to be readily attained. The performance of such an engine at constant pressure of supply is, within wide limits, proportionate to the quantity of the
380 working medium passed through the inlet port and it is practicable to carry, for indefinite intervals of time, an exceedingly great overload, by which I mean up to three or even four times the normal. Exceptional strength
385 and ruggedness of the motors being imperative in view of centrifugal stresses and violent

tion indicated by the dotted line. Owing to the increase of the coefficient of contraction and counterpressure attendant the enlargement of the inlet, the same should be made of
405 ample section.

Figure 5 shows a different means for attaining the same purpose. In this case the motors operate like true turbines, the working fluid being fully expanded, or nearly so,
410 through divergent exchangeable nozzles as 15, having a throat of sufficient section for the passage of fluid required during maximum performance. The exhaust opening is also correspondingly enlarged, though not necessarily
415 to the extent indicated in Figure 4. The power is varied by means of a throttle valve 16, as used in automobiles, located in the conduit supplying the air and carbureted fuel to the fluid pressure generator and mechanically
420 connected to the controlling lever 14. This apparatus is of a capacity adequate to the maximum demand by which I do not mean that it is necessarily much larger than required for
425 normal performances, but is merely designed to supply the working fluid or, broadly stated, energy—whenever desired, at a rate greatly exceeding the normal. In Figure 3 this apparatus is diagrammatically indicated by 17, and may
430 be any one of a number of well-known types, producing pressure by internal combustion of a suitable fuel or by external firing of a steam boiler. In the latter case, with constant pressure, the arrangement shown in Figure 4 is
435 best to employ, while the plane illustrated in Figure 5 can be used to advantage when both pressure and quantity of fluid are varied.

In operation for vertical ascent, the machine being in the attitude of Figure 1, the aviator will push forward lever 14 and supply sufficient
440 primary energy to the motors for lifting the machine with the desired velocity. When the objective elevation is reached rudders 7, 7 are manipulated to incline the machine at a certain angle, the aviator simultaneously applying
445 more pressure to the lever and augmenting the fluid supply to the motors, thereby increasing the propeller thrust in the vertical direction so as to prevent the machine from descending. He continues these operations always coordi-
450 nation the thrust developed with the changes

THE COMPLETE PATENTS OF NIKOLA TESLA

UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y.

APPARATUS FOR AERIAL TRANSPORTATION.

SPECIFICATION forming part of Letters Patent No. 1,655,114, dated January 3, 1928.
Application filed October 4, 1927. Serial No. 223,915.

This application is a continuation in part of my application Serial No. 499,518, filed September 9, 1921, and is made pursuant to the rules of the Patent Office, its purpose being to describe and claim apparatus which I have invented for carrying into practice the method therein disclosed.

The invention consists of a new type of flying machine, designated "helicopter-plane", which may be raised and lowered vertically and driven horizontally by the same propelling devices and comprises: a prime mover of improved design and an airscrew, both especially adapted for the purpose, means for tilting the machine in the air, arrangements for controlling its operation in any position, a novel landing gear and other constructive details, all of which will be hereinafter fully described.

The utility of the aeroplane as a means of transport is materially lessened and its commercial introduction greatly hampered owing to the inherent inability of the mechanism to readily rise and alight, which is an unavoidable consequence of the fact that the required lifting force can only be produced by a more or less rapid translatory movement of the planes or foils. This indispensable high velocity, imperilling life and property, makes it necessary to equip the machine with special appliances and provide suitable facilities at the terminals of the route, all of which entail numerous drawbacks and difficulties of a serious nature.

velocities of the projected air particles; symbolically expressed,

$$T = \Sigma (mv).$$

On the other hand, the kinetic energy of the air set in motion is

$$E = \Sigma \left(\frac{mv^2}{2} \right).$$

From these equations it is evident that a great thrust can be obtained with a comparatively small amount of power simply by increasing the aggregate mass of the particles and reducing their velocities. But the seemingly great gain thus secured is of small value in aviation for the reason that a high speed of travel is generally an essential requirement which cannot be fulfilled except by propelling the air at high velocity, and that obviously implies a relatively small thrust.

Another quality commonly attributed to the helicopter is great stability, this being apparently a logical inference judging from the location of the centers of gravity and pressure. It will be found, though, that contrary to this prevailing opinion the device, while moving in any direction other than up or down, has an equilibrium easily disturbed and has, moreover, a pronounced tendency to oscillate.

In explanation of these and other peculiarities, assume the helicopter poised in still air

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90 curve to a level below and if the inclination of the propeller as well as its speed of rotation remain unaltered during the descent, the forces T , T_1 , and T_2 will continuously increase in proportion to the density of the air until
95 the vertical component T_1 of the axial thrust T becomes equal to the gravitational attraction. The extent of the drop will be governed by the inclination of the propeller axis and for a given angle it will be, theoretically,
100 the same no matter at what altitude the events take place. To get an idea of its magnitude suppose the elevations of the upper and lower strata measured from sea level be h_1 and h_2 , respectively, d_1 and d_2 the corresponding air
105 densities and $H = 26,700$ feet the height of the "uniform atmosphere," then as a consequence of Boyle's Law the relation will exist

$$h_1 - h_2 = H \log_e \frac{d_2}{d_1}$$

It is obvious that

$$110 \frac{T}{T_1} = \frac{T}{T \sin \alpha} = \frac{1}{\sin \alpha} \text{ must be equal to } \frac{d_1}{d_2}$$

in order that the vertical component of the axial thrust in the lower stratum should just support the weight. Hence

$$H_1 - h_2 = H \log_e \frac{1}{\sin \alpha}$$

115 Taking, in a special case, the angle $\alpha = 60$ degrees, then

$$\frac{1}{\sin \alpha} = \frac{1}{0.866} = 1.1547, \text{ and}$$

$$h_1 - h_2 = 26,700 \times \log_e 1.1547 = 3,840 \text{ feet.}$$

120 In reality the drop will be much greater for the machine, upon reaching the lower layer with a high velocity relative to the medium, will be urged further down along the curved path and the kinetic energy, in the vertical sense, possessed by the moving mass must be
125 annihilated before the fall is arrested in a still denser air stratum. At this point the upward

was supposed to move always parallel to itself, which result might be accomplished by the use of an adjustable aileron. In this connection it may be pointed out, however, that such a
145 device will not act in the manner of a rudder, coming into full play at the intervals only and performing its functions economically, but will steadily absorb energy, this occasioning a considerable waste of motive power and add-
150 ing another to the many disadvantages of the helicopter.

Let now the machine be possessed of a certain degree of freedom, as will be the case normally, and observe in the first place that
155 the blades of the propeller themselves constitute planes developing a reaction thrust, the pressure on the lower leading blade being greater than that exerted on the higher one owing to the compression of the air by the
160 body of the machine and increased density in that region. This thrust tending to diminish the angle α , will vary during one revolution, being maximum in a position when the line of symmetry of the two propeller blades and
165 that of flight are in the same vertical plane and minimum when the former is at right angles to it. Nevertheless, if the horizontal speed is great, it may be considerable and sufficient to quickly overcome the inertia and gy-
170 roscopic resistances all the more readily as the upper blade operates to the same effect. Moreover, this intermittent action partakes of the regenerative quality, the force increasing as the angle diminishes up a maximum for $\alpha = 45$
175 degrees, and may also give rise to disturbing resonant vibrations in the structure. As its axis is tilted more and more, the vertical sustaining effort of the propeller correspondingly diminishes and the machine will fall with a rapidly
180 increasing velocity, which may finally exceed the horizontal, when the reaction of the blades is directed upward so as to increase the angle α and thereby cause the machine to soar
185 higher. Thus periodic oscillations, accompanied by ascents and descents, will be set up which may well be magnified to an extent such as to bring about a complete overturn and plunge to earth.

It is held by some experts that the helicop-
190 ter, because of its smaller body resistance,

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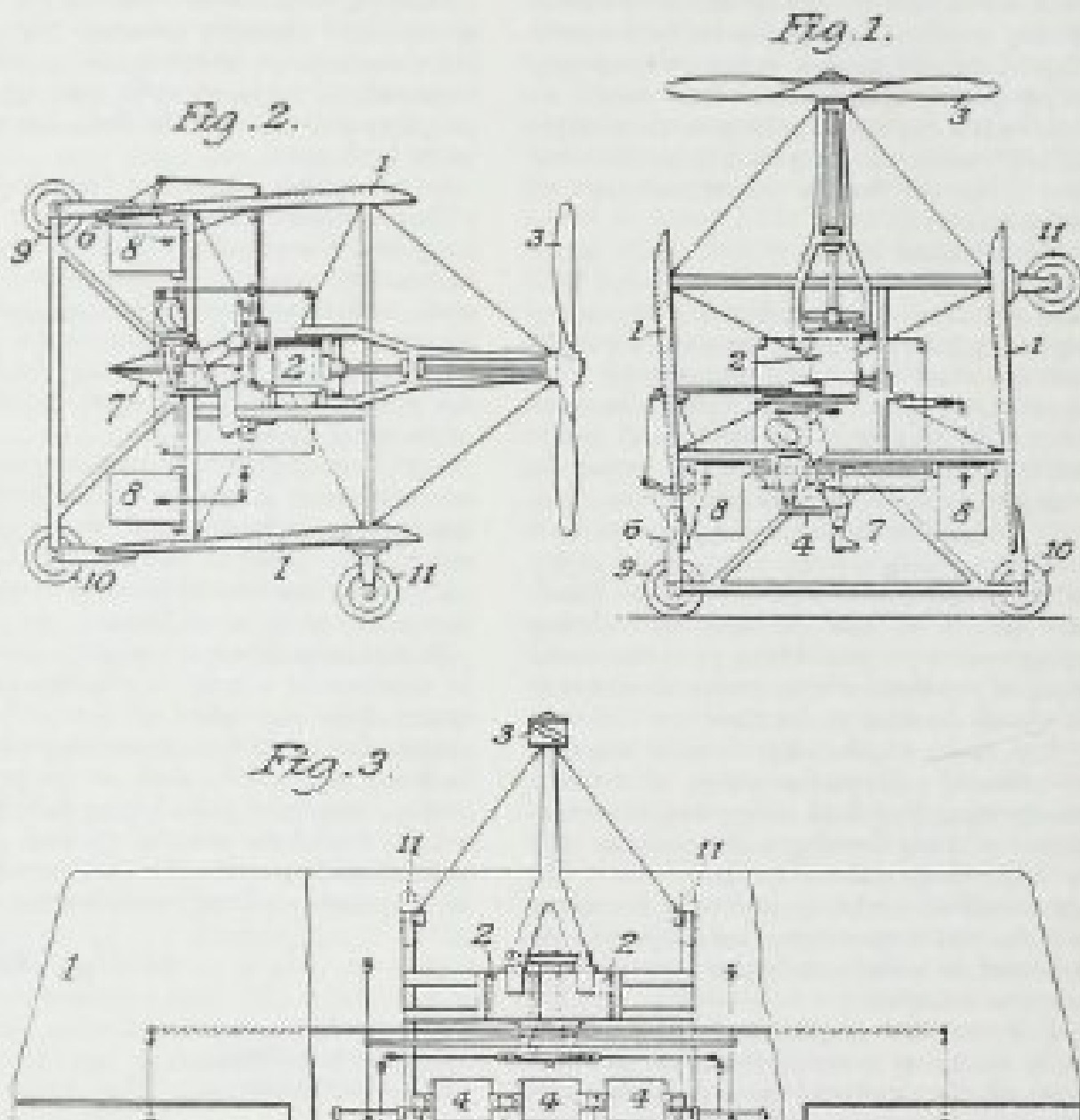
Jan. 3, 1928.

N. TESLA

1,655,113

METHOD OF AERIAL TRANSPORTATION

Filed Sept. 9, 1921



THE COMPLETE PATENTS OF NIKOLA TESLA

UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y.

METHOD OF AERIAL TRANSPORTATION.

SPECIFICATION forming part of Letters Patent No. 1,655,113, dated January 3, 1928.

Application filed September 9, 1921. Serial No. 499,519, and in Great Britain April 1, 1921.

The utility of the aeroplane as a means of transport is materially lessened and its commercial introduction greatly hampered owing to the inherent inability of the mechanism to readily rise and alight, which is an unavoidable consequence of the fact that the required lifting force can only be produced by a more or less rapid translatory movement of the planes or foils. In actual experience the minimum speed for ascension and landing is a considerable fraction of that in full flight, and the principles of design do not admit of a very great advance in this respect without sacrifice of some desirable feature. For this reason planes of very large area, high lift wing-sections, deflectors of the slip-stream of the propeller, or analogous means, which might be helpful in these operations, do not afford the remedy sought. This indispensable high velocity, imperilling life and property, makes it necessary to equip the machine with special appliances and provide suitable facilities at the terminals of the route, all of which entail numerous drawbacks and difficulties of a serious nature. So imperative has it become to devise some plan of doing away with these limitations of the aeroplane that the consensus of expert opinion characterizes the problem as one of the most pressing and important and its practical solution is eagerly awaited by those engaged in the development of the art, as well as the general public.

Many attempts have been made to this end, mostly based on the use of independent de-

propeller alone. However, although this idea is quite old and not a few experts have endeavored to carry it out in various ways, no success has as yet been achieved. Evidently, this is due to the inadequacy of the engines employed and, perhaps, also to certain heretofore unsuspected characteristics of the device and fallacies in the accepted theory of its operation, an elucidation of which is deemed necessary for the clear understanding of the subject.

The prospects of a flying machine of this kind appear at first attractive, primarily because it makes possible the carrying of great loads with a relatively small expenditure of energy. This follows directly from the fundamental laws of fluid propulsion, laid down by W. T. M. Rankine more than fifty years ago, in conformity with which the thrust is equal to the integral sum of the products of the masses and velocities of the projected air particles; symbolically expressed,

$$T = \Sigma(mv).$$

On the other hand, the kinetic energy of the air set in motion is

$$E = \Sigma(\frac{1}{2}mv^2).$$

From these equations it is evident that a great thrust can be obtained with a comparatively small amount of power simply by increasing the aggregate mass of the particles and reducing their velocities. Taking a special case for

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the main piston, and a chamber or cylinder
therefor, containing air which is normally, at
the same pressure as the external atmosphere,
for thus a spring of practically constant rigid-
ity is obtained, but the air or gas within the
cylinder may be maintained at any pressure.

In order to describe the best manner of
which I am aware in which the invention is
or may be carried into effect, I refer now to
the accompanying drawing which represents
in central cross-section an engine embodying
any improvements.

A is the main cylinder in which works a
piston B. Inlet ports C C pass through the
sides of the cylinder, opening at the middle
portion thereof and on opposite sides. Exhaust
ports D D extend through the walls of the
cylinder and are formed with branches that
open into the interior of the cylinder on each
side of the inlet ports and on opposite sides
of the cylinder.

The piston B is formed with two circumfer-
ential grooves E F, which communicate
through openings G in the piston with the
cylinder on opposite sides of said piston
respectively.

I do not consider as of special importance
the particular construction and arrangement of
the cylinder, the piston and the ports for con-
trolling it, except that it is desirable that all
the ports, and more especially, the exhaust
ports should be made very much larger than
is usually the case, so that no force due to the
action of the steam or compressed air will tend
to retard or affect the return of the piston in
either direction.

The piston B is secured to a piston rod H,
which works in suitable stuffing boxes in the
heads of the cylinder A. This rod is prolonged
on one side and extends through bearings V
in a cylinder I suitably mounted or supported
in line with the first, and within which is a
disk or plunger J carried by the rod H.

The cylinder I is without ports of any kind
and is air-tight except as a small leakage may
occur through the bearings V, which experi-
ence has shown need not be fitted with any
very considerable accuracy. The cylinder I is
surrounded by a jacket K which leaves an
open space or chamber around it. The bear-

sides and drip pipes Q leading out from it
through which the oil which collects in it is
carried off.

To explain now the operation of the device
above described. In the position of the parts
shown, or when the piston is at the middle
point of its stroke, the plunger J is at the
center of the cylinder I and the air on both
sides of the same is at the normal pressure of
the outside atmosphere. If a source of steam
or compressed air be then connected to the
inlet ports C C of the cylinder A and a move-
ment be imparted to the piston as by a sudden
blow, the latter is caused to reciprocate in a
manner well understood. The movement of
the piston in either direction ceases when the
force tending to impel it and the momentum
which it has acquired are counterbalanced by
the increasing pressure of the steam or com-
pressed air in that end of the cylinder toward
when it is moving and as in its movement the
piston has shut off at a given point, the pres-
sure that impelled it and established the pres-
sure that tends to return it, it is then impelled
in the opposite direction, and this action is
continued as long as the requisite pressure is
applied. The movements of the piston com-
press and rarify the air in the cylinder I at
opposite ends of the same alternately. A for-
ward stroke compresses the air ahead of the
plunger J which acts as a spring to return it.
Similarly on the back stroke the air is com-
pressed on the opposite side of the plunger J
and tends to drive it forward. This action of
the plunger upon the air contained in the op-
posite ends of the cylinder is exactly the same
in principle as though the piston rod were
connected to the middle point of a coiled
spring, the ends of which are connected to
fixed supports. Consequently the two cham-
bers may be considered as a single spring. The
compressions of the air in the cylinder I and
the consequent loss of energy due mainly to
the imperfect elasticity of the air, give rise to
a very considerable amount of heat. This heat
I utilize by conducting the steam or com-
pressed air to the engine cylinder through the
chamber formed by the jacket surrounding the
air-spring cylinder. The heat thus taken up
and used to raise the temperature of the steam

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tion of the piston however is no more depen-
230 dent upon the pressure applied to drive it,
than would be the period of oscillation of a
pendulum permanently maintained in vibra-
tion, upon the force which periodically impels
it, the effect of variations in such force being
235 merely to produce corresponding variations in
the length of stroke or amplitude of vibration
respectively. The period is mainly determined
by the rigidity of the air spring and the inertia
of the moving system, and I may therefore
240 secure any period of oscillation within very
wide limits by properly portioning these fac-
tors, as by varying the dimensions of the air
chamber which is equivalent to varying the
rigidity of the spring, or by adjusting the
245 weight of the moving parts. These conditions
are all readily determinable, and an engine
constructed as herein described may be made
to follow the principle of operation above
stated and maintain a perfectly uniform period
250 through very much wider limits of pressure
than in ordinary use, it is ever likely to be
subjected to and it may be successfully used
as a prime mover wherever a constant rate of
oscillation or speed is required, provided the
255 limits within which the forces tending to bring
the moving system to a given position are pro-
portionate to the displacements, are not mate-
rially exceeded. The pressure of the air
confined in the cylinder when the plunger J
260 is in its central position will always be practi-
cally that of the surrounding atmosphere, for
while the cylinder is so constructed as not to
permit such sudden escape of air as to sensibly
impair or modify the action of the air spring
265 there will be a slow leakage of air into or out
of it around the piston rod according to the
pressure therein, so that the pressure of the air
on opposite sides of the plunger will always
tend to remain at that of the outside
270 atmosphere.

As an instance of the uses to which this
engine may be applied I have shown its piston
rod connected with a pawl R the oscillation
of which drives a train of wheels. These may
275 constitute the train of a clock or of any other
mechanism. The pawl R is pivoted at R' and
its bifurcated end engages with the teeth of
the ratchet wheel alternately on opposite sides

the engine render it especially adapted for use 290
in small sizes or units.

Having now described my invention, what
I claim is—

1. A reciprocating engine comprising in
combination, a cylinder, a piston and a spring 295
connected with or acting upon the reciprocating
element, the said spring and reciprocating
element being related in substantially the man-
ner described so that the forces which tend to
bring the reciprocating parts into a given posi- 300
tion are proportionate to the displacements,
whereby an isochronous vibration is obtained.

2. A reciprocating engine comprising in
combination, a cylinder, a piston impelled by
steam or gas under pressure, and an air spring 305
maintained in vibration by the movements of
the piston, the piston and spring being related
in substantially the manner described so that
the forces which tend to bring the reciprocating
parts into a given position are proportionate to 310
the displacements whereby an isochronous vi-
bration is obtained.

3. The combination of a cylinder and a
piston adapted to be reciprocated by steam or
gas under pressure, a cylinder and a plunger 315
therein reciprocated by the piston and consti-
tuting an air spring acting upon said piston,
the piston and spring being related in the
manner described so that the forces which
tend to bring the piston into a given position 320
are proportionate to the displacement whereby
an isochronous oscillation of the piston is
obtained.

4. The combination of a cylinder and a
piston adapted to be reciprocated by steam 325
or gas under pressure, a cylinder and piston
constituting an air spring connected with the
piston, a jacket forming a chamber around the
air spring through which the steam or com-
pressed gas is passed on its way to the cylinder, 330
as and for the purpose set forth.

5. The method of producing isochronous
movement herein described, which consists in
reciprocating a piston by steam or gas under
pressure and controlling the rate or period of 335
reciprocation by the vibration of a spring, as
set forth.

6. The method of operating a reciprocating
engine which consists in reciprocating a pis-

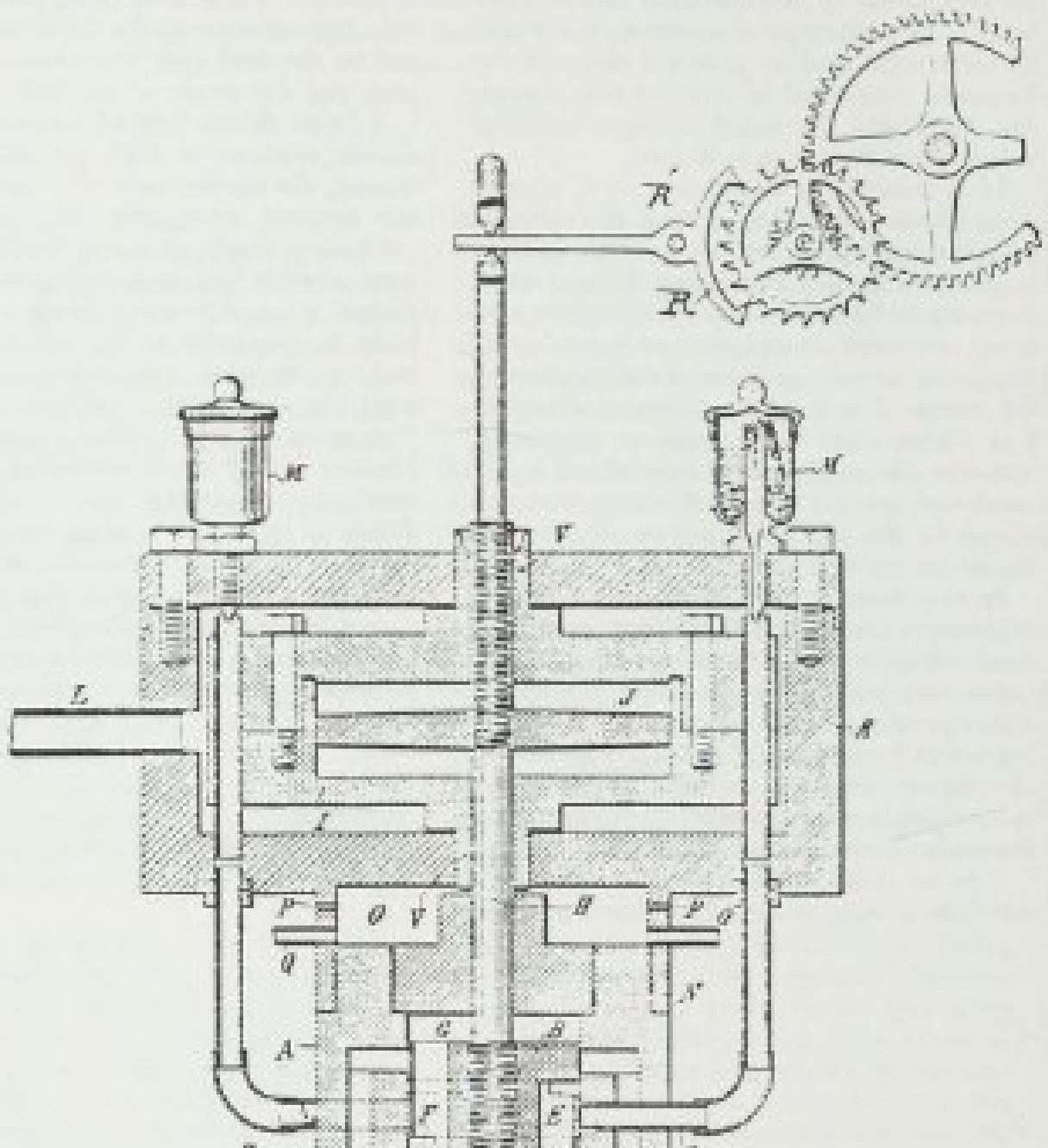
THE COMPLETE PATENTS OF NIKOLA TESLA

(No Model.)

N. TESLA.
RECIPROCATING ENGINE.

No. 514,169.

Patented Feb. 6, 1894.



THE COMPLETE PATENTS OF NIKOLA TESLA

UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y.

RECIPROCATING ENGINE.

SPECIFICATION forming part of Letters Patent No. 514,169, dated February 6, 1894.

Application filed August 19, 1893. Serial No. 483,363. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York have
5 invented certain new and useful Improvements in Reciprocating Engines, of which the following is a specification, reference being had to the drawing accompanying and forming a part of the same.

10 In the invention which forms the subject of my present application, my object has been, primarily to provide an engine, which under the influence of an applied force such as the elastic tension of steam or gas under pressure
15 will yield an oscillatory movement which, within very wide limits, will be of constant period, irrespective of variations of load, frictional losses and other factors which in all ordinary engines produce change in the rate of
20 reciprocation.

The further objects of the invention are to provide a mechanism, capable of converting the energy of steam or gas under pressure into mechanical power more economically than the
25 forms of engine heretofore used, chiefly by overcoming the losses which result in these by the combination with rotating parts possessing great inertia of a reciprocating system; which also, is better adapted for use at higher tem-
30 peratures and pressures, and which is capable of useful and practical application to general industrial purposes, particularly in small units.

tion are entirely obviated. On the other hand, 50
in certain cases, where reciprocating engines or tools have been used without a rotating system of great inertia, no attempt, so far as I know, has been made to secure conditions which would necessarily yield such results as
55 I have reached.

It is a well known principle that if a spring possessing a sensible inertia be brought under tension, as by being stretched, and then freed it will perform vibrations which are isochro- 60
nous and, as to period, in the main dependent upon the rigidity of the spring, and its own inertia or that of the system of which it may form an immediate part. This is known to be
65 true in all cases where the force which tends to bring the spring or movable system into a given position is proportionate to the displacement.

In carrying out my invention and for securing the objects in general terms stated above, I employ the energy of steam or gas under 70
pressure, acting through proper mechanisms, to maintain in oscillation a piston, and, taking advantage of the law above stated, I connect with said piston, or cause to act upon it, a
spring, under such conditions as to automati- 75
cally regulate the period of the vibration, so that the alternate impulses of the power impelled piston, and the natural vibrations of the spring shall always correspond in direction and
80 coincide in time.

While, in the practice of the invention I

THE COMPLETE PATENTS OF NIKOLA TESLA

(No Model.)

N. TESLA.
ELECTRIC RAILWAY SYSTEM.

No. 514,972.

Patented Feb. 20, 1894.

Fig. 1

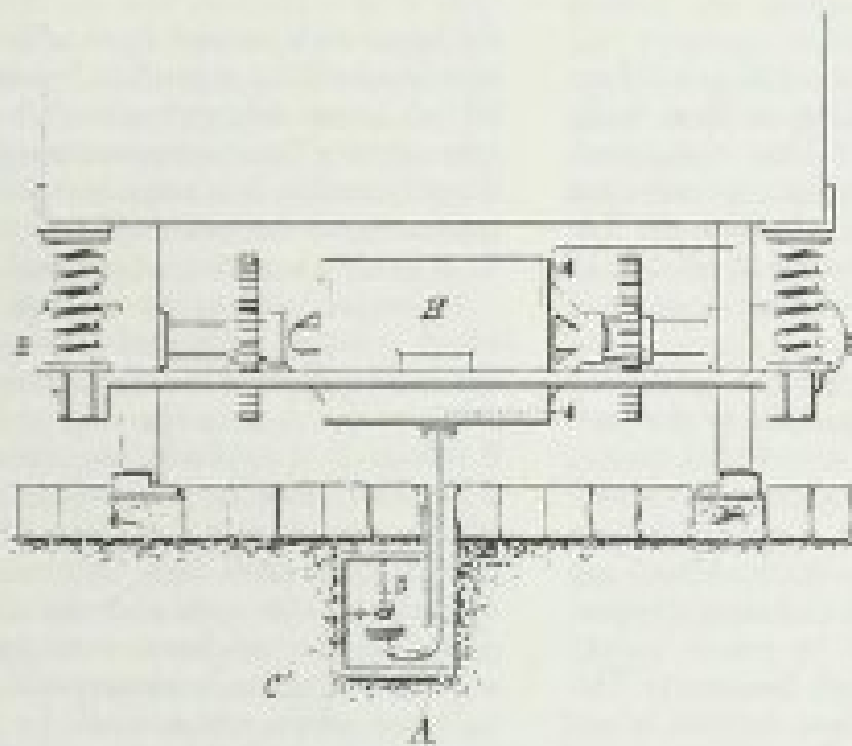


Fig. 2



Fig. 3



THE COMPLETE PATENTS OF NIKOLA TESLA

PATENTS FOR ENGINES & PROPULSION

With the exception of his patented electric railway system (No. 514,972), Tesla's contributions to the field of propulsion are complete departures from electrical thinking—exhibiting range and versatility often neglected in later accounts of his work.

Of course no one, least of all in the Patent Office, was exactly howled over in 1893 by yet another reciprocating steam engine (No. 514,169; No. 517,900). Tesla had only dabbled in this workaday technology as a means to obtaining more wieldy and regular oscillating machines, chiefly to power electrical generators. The vibratory frequencies he obtained were stable enough, as he demonstrated, to run motors as the timekeeping element in clocks. His designs, with typical elegance, reduce moving parts and eliminate heavy dampers, like flywheels, in favor of air springs, or dash pots.

His mechanisms for fluid propulsion (No. 1,061,142; No. 1,061,206) introduced to the world a flat-disc, vaneless turbine. And for the most part, the world was puzzled. The notion of frictionally coupling a fluid stream to stacks of critically spaced, smooth plates—minimizing energy lost in turbulence—simply lacked a wide engineering acquaintance. Its advantages should have been clear, but few were sold, and those mostly under license in Europe.

Although such turbines provide higher efficiency and simpler manufacture than other types, they have only recently been developed and used in a serious way. To be sure, these turbines could reach operational speeds (ca. 30,000 rpm) that overwhelmed the best materials available in his day. Tesla himself built successful models of up to 200 hp and adapted the idea to several improved rate-measuring devices.

Straitened circumstances and a deteriorating state of mind interrupted and eventually halted his patent applications. Of the last eight filed, in 1922, but abandoned in process, six pertained to fluid mechanics and technical enlargements of his turbine systems.

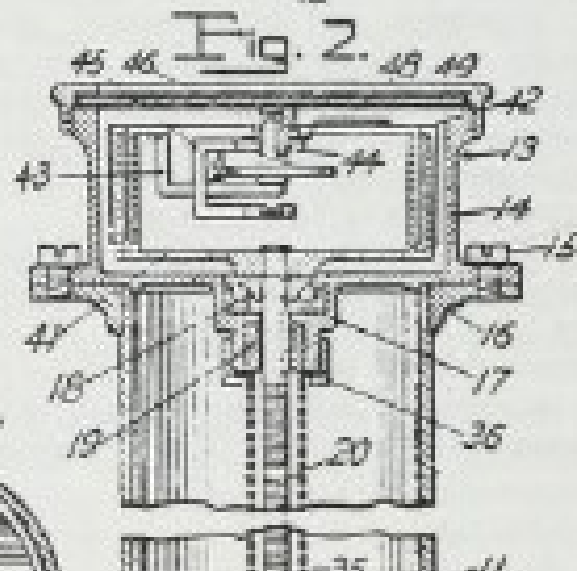
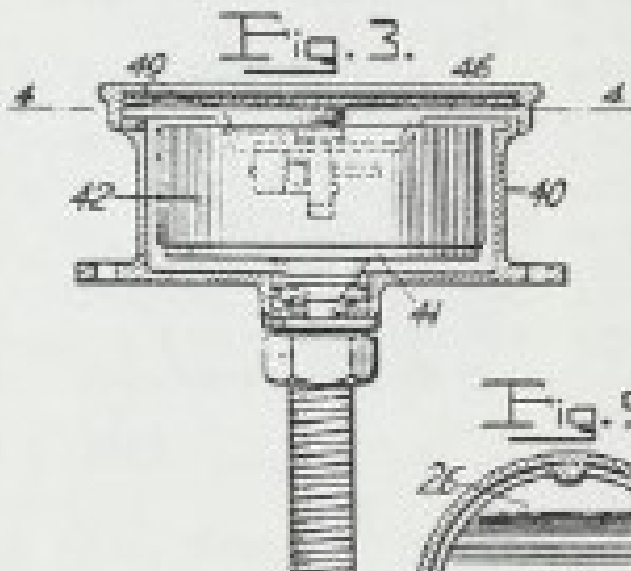
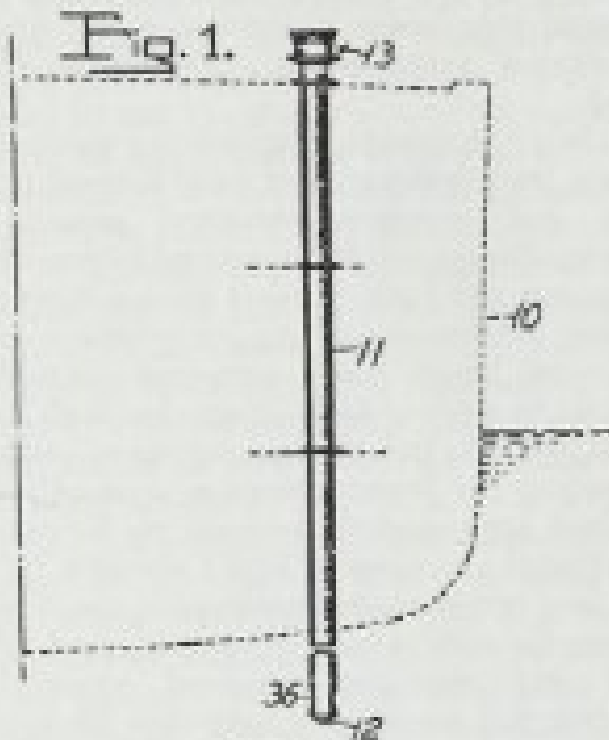
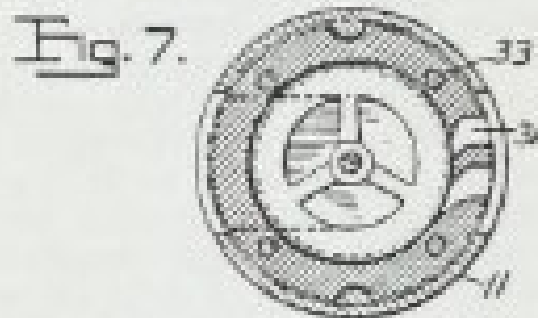
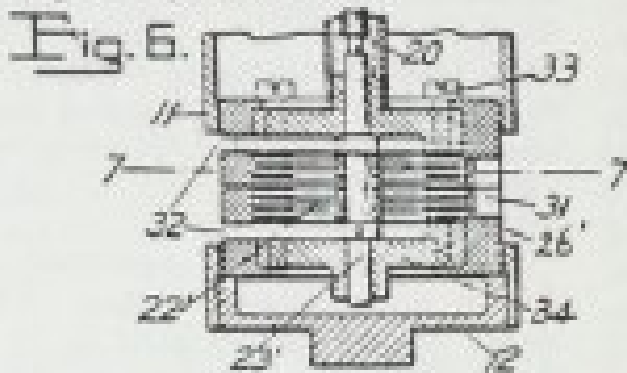
He made also of turbine-powered motors what he eventually drew up, however, were

THE COMPLETE PATENTS OF NIKOLA TESLA

N. TESLA.
SHIP'S LOG.
APPLICATION FILED DEC. 18, 1918.

Patented Sept. 2, 1919.

1,314,718.



THE COMPLETE PATENTS OF NIKOLA TESLA

UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR TO WALTHAM WATCH
COMPANY, OF WALTHAM, MASSACHUSETTS, A CORPORATION
OF MASSACHUSETTS.

SHIP'S LOG.

1,314,718.

Specification of Letters Patent.

Patented Sept. 2, 1919.

Application filed December 18, 1916. Serial No. 137,690

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen
of the United States, residing at New York,
in the county and State of New York, have
invented certain new and useful Improvements
in Ships' Logs, of which the following is a
full, clear, and exact description.

My invention provides a ship's log of novel
and advantageous construction and operation,
designed to give instantaneous rate-readings,
as in knots, or miles per hour. The customary
log is trailed astern, twisting the flexible con-
nector that drives a revolution-counter on the
vessel, and many disadvantages of such ar-
rangement are obvious.

In my instrument I combine very advanta-
geously a propeller rotatable proportionately
to vessel-speed and a speed indicator driven
by it and reading directly in the desired terms,
preferably upon a substantially uniformly-
graduated scale.

In the drawings, Figure 1 diagrams the log
in use.

Fig. 2 shows it in vertical section;

Fig. 3 illustrates speed-indicator parts with
the casing broken away;

Fig. 4 is a section on line 4—4 of Fig. 3;

Fig. 5 is a section on line 5—5 of Fig. 2.

Fig. 6 shows in section a turbine form of
propeller, and

Fig. 7 is a section on line 7—7 of Fig. 6.

To the vessel 10, preferably near its bow, is
suitably affixed a tube or barrel, 11, with a
disposed along its length, in lower and upper

a housing 26 that fits nearly in the barrel and
is held in register with ports 27 and 28 by
guide-ribs 29. Such a propeller drives the shaft
20 through bevel gears 30.

More advantageously in some respects,
however, a turbine propeller of simple con-
struction may be employed, as shown in Figs.
6 and 7. The rotor in this instance has a
vertical shaft 23' and the wheel 22' is formed
of thin, parallel, closely-spaced disks each hav-
ing a central opening. The wheel is arranged
in a cylindrical housing 26' that has inlet noz-
zles 31 and outlet ports 32 so disposed that
the water enters the interspaces between the
disks tangentially to rotate the wheel and finds
escape through the ports 32 that communicate
with the central orifices of the disks. This type
of construction has many advantages due to
its reliability and efficiency, but preferably it
should be constructed to permit the disks and
casing to be readily cleaned, casing 26' being
made in two horizontal sections bolted to-
gether as at 33, each section having a detach-
able head 34.

A flexible and longitudinally elastic sleeve,
35, of coiled strip metal is fastened at opposite
ends by threaded caps 36 and 37 to the boss
17 and to a threaded part on the propeller
casing, so that the propeller mechanism is sup-
ported from the indicator casing for removal
therewith.

By suitably constructing the submerged
parts of bronze, enameling them, or otherwise
making them substantially immune to corrosion,

THE COMPLETE PATENTS OF NIKOLA TESLA

THE COMPLETE PATENTS OF NIKOLA TESLA

UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y.

METHOD OF OPERATING ARC LAMPS.

SPECIFICATION forming part of Letters Patent No. 447,920, dated March 10, 1891.

Application filed October 1, 1890. Serial No. 366,734. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria-Hungary, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Methods of Operating Arc Lamps, of which the following is a specification.

This invention consists in an improved method of operating electric-arc lamps which are supplied with alternating or pulsating currents.

It has now become a common practice to run arc lamps by alternating or pulsating as distinguished from continuous currents; but an objection to such systems exists in the fact that the arcs emit a pronounced sound, varying with the rate of the alternations or pulsations of current, but under any circumstances constituting an objectionable and disagreeable feature, for which heretofore no effective remedy has been found or proposed. This noise is probably due to the rapidly alternating heating and cooling and consequent expansion and contraction of the gaseous matter forming the arc which corresponds with the periods or impulses of the current, for I have succeeded in abating it and producing quiet and smoothly-acting lamps by increasing, per unit of time, the number of alternations or pulsations of the current producing the arc to such an extent

Figure 1 is a view of the generator in side elevation. Fig. 2 is a vertical cross-section of the same with a diagram of the circuit-connections. Fig. 3 is an enlarged view, in side elevation, of a part of the machine. Fig. 4 is an enlarged sectional detail of the armature and field. Fig. 5 is a detail section of the field-magnets exhibiting the plan of winding.

A is an annular magnetic frame supported by the cross-bars or brackets B, provided with feet C, upon which the machine rests. The interior of the annulus A is provided with a large number of projections or pole-pieces D. These may be formed or applied in a variety of ways—as, for example, by milling transverse grooves E.

Owing to the very large number and small size of the poles and the spaces between them, I apply the exciting or field coils by winding an insulated conductor F zigzag through the grooves, as shown in Fig. 3, carrying said wire around the annulus to form as many layers as is desired. In this way the pole-pieces D will be energized with alternately opposite polarity around the entire ring.

For the armature I employ a spider or circular frame G on a driving-shaft H, mounted in bearings in the brackets B. This spider carries a ring J, turned down, except at its edges, to form a trough-like receptacle for a mass of fine

THE COMPLETE PATENTS OF NIKOLA TESLA

in series with the machine in Fig. 2. If such
100 a current be applied to running arc lamps,
the sound produced by or in the arc becomes
practically inaudible, for by increasing the rate
of change in the current, and consequently the
number of vibrations per unit of time of the
105 gaseous material of the arc up to or beyond
ten thousand or eleven thousand per second,
or to what is regarded as the limit of audition,
the sound due to such vibrations will not be
audible. The exact number of changes or un-
110 dulations necessary to produce this result will
vary somewhat according to the size of the
arc—that is to say, the smaller the arc the
greater the number of changes that will be
required to render it inaudible within certain
115 limits. Of course, as the rate of alternations
or undulations for a given size of arc becomes
very high the sound produced is less percepti-
ble, and hence for some purposes the actual
limit of audition may only be approached,
120 provided the sound be rendered practically
inaudible.

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Another advantage gained by increasing as above set forth the number of alternations is that the arc acts more like that produced by a continuous current, in that it is more persistent, owing to the fact that the time interval between undulations is so small that the gaseous matter cannot cool down so far as to increase very considerably in resistance. 125

I claim— 130

The method of abating or rendering inaudible the sound emitted by arc lamps supplied with or operated by an alternating or pulsating current by increasing the rate of such alternations or pulsations up to that of the limit of 135 audition, as set forth.

NIKOLA TESLA.

Witnesses:

FRANK B. MURPHY.

RAPHAEL NETTER.

THE COMPLETE PATENTS OF NIKOLA TESLA

of the magnet M, at the same time main-
230 taining by magnetic induction in the core of
shunt-magnet the required magnetism without
reversal of polarity, and the armature g re-
mains against the shunt-magnet pole n'. The
lamp is thus cut out as long as the carbons
235 are separated. The cut-out may be used in this
form without any further improvement; but I
prefer to arrange it so that if the rod drops
and the carbons come in contact the arc is
started again. For this purpose I proportion
240 the resistance of the part p' and the number
of the convolutions of the wire upon the main
magnet so that when the carbons come in
contact a sufficient amount of current is di-
verted through the carbons and the part x'
245 to destroy or neutralize the magnetism of the
compound magnet. Then the armature g, hav-
ing a slight tendency to approach to the
clamping-pole m', comes out of contact with
the releasing pole n'. As soon as this happens,
250 the current through the part p' is interrupted,
and the whole current passes through the part
x. The magnet M is now strongly magnetized,
the armature g is attracted, and the rod
clamped. At the same time the armature-lever
255 L is pulled down out of its normal position
and the arc started. In this way the lamp cuts
itself out automatically when the arc gets so
long, and reinserts itself automatically in the
circuit if the carbons drop together.

260 It will be seen that the cut-out may be
modified without departing from the spirit of
my invention, as long as the shunt-magnet
closes a circuit including a wire upon the main
magnet and continues to keep the contact
265 closed, being magnetized by magnetic induc-
tion from the main magnet. It is also obvious
to say that the magnets and armatures may be
of any desired shape.

I claim as my invention—

270 1. The combination, in an arc lamp, of a
main and a shunt magnet, an armature-lever
to draw the arc, a clamp, and an armature to
act upon the clamp, a clamping-pole and a
releasing-pole upon the respective cores, the
275 cores, poles, armature-lever, and clamping-
armature forming a compound electro-mag-
net, substantially as set forth.

armature-lever and connection from the same
to the clamp, the main and shunt magnets,
and the respective poles of the same to act
295 upon the clamping armature and armature-
lever, respectively, substantially as set forth.

4. In an electric-arc lamp, a cut-out con-
sisting of a main magnet, an armature, and a
shunt-magnet having an insulated pole-piece, 300
and the cut-out circuit-connections through
the pole-piece and armature, substantially as
set forth.

5. In an electric-arc lamp, the combination,
with the carbon-holder and magnets, of the 305
armatures l. and g, link e', clamp e, and lever
t, and the spring s', for the purpose set forth.

6. In an electric arc lamp, the combination,
with two upright magnets in the main and
shunt circuits, respectively, having curved 310
pole-pieces on one end and converging pole
pieces on the other end, of a flat Z-shaped
armature-lever between the curved pole-pieces
and a clamping-armature between the conver-
gent pole-pieces, substantially as described. 315

7. The combination, in an electric-arc lamp
of an electro-magnet in the main circuit and
an electro-magnet in the shunt-circuit, an ar-
mature under the influence of the poles of the
respective magnets, and circuit-connections 320
controlled by such armature to cut out or
shunt the lamp, substantially as specified,
whereby the branch circuit is closed by the
magnetism of the shunt-magnet, and then
kept closed by induced magnetism from the 325
main magnet, substantially as set forth.

8. The combination, with the carbon-
holder and rod and the main and shunt mag-
nets, of a feeding-clamp, an armature for the
same, clamping and releasing poles upon the 330
cores of the respective magnets, and circuit-
connections through the clamping armature,
substantially as specified, for shunting the cur-
rent when the electric arc between the carbons
becomes abnormally long, substantially as set 335
forth.

9. The combination, with the carbon-hold-
ing rod and a clamp for the same, of an arma-
ture upon the clamp, a shunt-magnet the pole
of which acts to release the clamp, and a main 340
magnet with a two-part helix, one portion

THE COMPLETE PATENTS OF NIKOLA TESLA

(No Model.)

N. TESLA.
METHOD OF OPERATING ARC LAMPS.

No. 447,920.

Patented Mar. 10, 1891.

Fig. 1

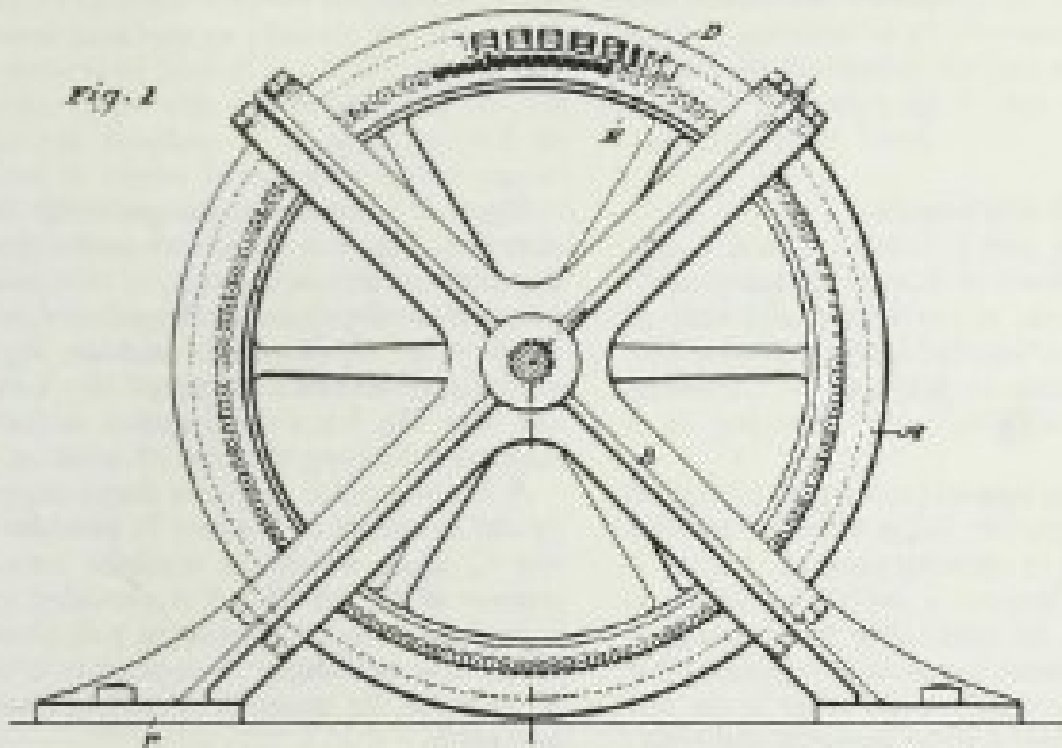


Fig. 4

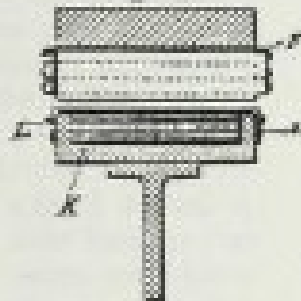


Fig. 3



Fig. 5

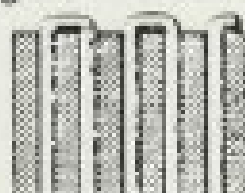
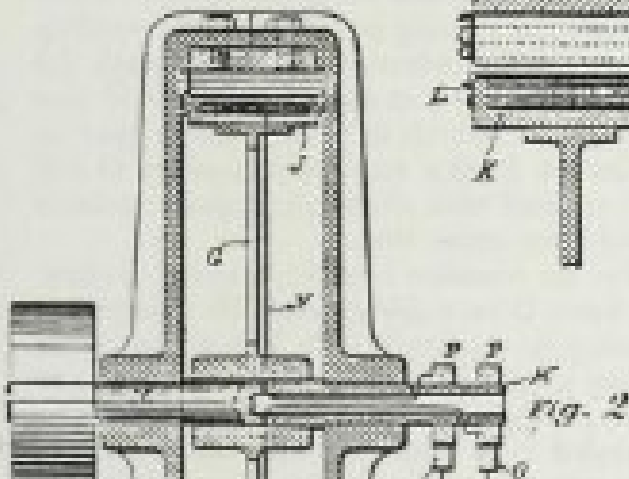


Fig. 2



THE COMPLETE PATENTS OF NIKOLA TESLA

UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF SMILJAN LIKA, AUSTRIA-HUNGARY, ASSIGNOR TO
THE TESLA ELECTRIC LIGHT AND MANUFACTURING COMPANY, OF
RAHWAY, NEW JERSEY.

ELECTRIC-ARC LAMP.

SPECIFICATION forming part of Letters Patent No. 335,787, dated February 9, 1886.
Application filed July 15, 1885, Serial No. 171,416. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, of Smiljan Lika, border country of Austria-Hungary, have invented certain improvements in Electric-Arc Lamps, of which the following is a specification.

In another application, No. 160,574, filed by me March 30, 1885, I have shown and described a lamp having two magnets, in the main and shunt circuits, respectively, an armature-lever, and feed-mechanism connected to the armature-lever.

My present invention consists in some modifications of and improvements upon the devices shown in the application referred to.

In my present invention I further provide means for automatically withdrawing a lamp from the circuit, or cutting out the same, when, from a failure of the feed, the arc reaches an abnormal length, and also means for automatically reinserting such lamp in the circuit when the rod drops and the carbons come into contact.

My invention will be understood with reference to the accompanying drawings.

In the drawings, Figure 1 is an elevation of the lamp with the case in section, Fig. 2 is a sectional plan at the line *x x*, Fig. 3 is an elevation, partly in section, of the lamp at right angles to Fig. 1, Fig. 4 is a sectional plan

50
cient to produce the required magnetism, besides a greater surface is offered for cooling off the wires.

The upper pole-pieces, *m n*, of the magnets are curved, as indicated in the drawings, Fig. 1. The lower pole-pieces, *m' n'*, are brought 55
near together, tapering toward the armature *g*, as shown in Figs. 2 and 4. The object of this taper is to concentrate the greatest amount of the developed magnetism upon the armature, and also to allow the pull to be exerted always 60
upon the middle of the armature *g*. This armature *g* is a piece of iron in the shape of a hollow cylinder, having on each side a segment cut away, the width of which is equal to the width of the pole-pieces *m' n'*. 65

The armature is soldered or otherwise fastened to the clamp *r*, which is formed of a brass tube, provided with gripping-jaws *r r*, Fig. 5. These jaws are arcs of a circle of the diameter of the rod *R*, and are made of some 70
hard metal, preferably of hardened German silver. I also make the guides *f f*, through which the carbon-holding rod *R* slides, of the same material. This has the advantage to reduce greatly the wear and corrosion of the 75
parts coming in frictional contact with the rod, which frequently causes trouble. The jaws *r r* are fastened to the inside of the tube *r*, so that one is a little lower than the other. The

THE COMPLETE PATENTS OF NIKOLA TESLA

the overweight of the moving parts a spring, 100 s' , Figs. 2 and 6, is fastened to the top plate, B, and hooked to the lever t . The hook s is toward one side of the lever or bent a little sidewise, as seen in Fig. 6. By this means a slight tendency is given to swing the armature 105 toward the pole-piece m' of the main magnet.

The binding-posts K K' are preferably screwed to the base A. A manual switch, for short-circuiting the lamp when the carbons are renewed, is also to be fastened to the base. 110 This switch is of ordinary character, and is not shown in the drawings.

The rod R is electrically connected to the lamp-frame by means of a flexible conductor or otherwise. The lamp-case, receives a removable ornamental cover, s' , around the same to 115 inclose the parts.

The electrical connections are as indicated diagrammatically in Fig. 7.

The wire in the main magnet consists of 120 two parts, x' and p' . These two parts may be in two separated coils or in one single helix, as shown in the drawings. The part x' being normally in circuit, is, with the fine wire upon the shunt-magnet, wound and traversed by the 125 current in the same direction, so as to tend to produce similar poles, n n or s s , on the corresponding pole-pieces of the magnets M and N. The part p' is only in circuit when the lamp is cut out, and then the current being in 130 the opposite direction produces in the main magnet magnetism of the opposite polarity.

The operation is as follows: At the start the carbons are to be in contact, and the current passes from the positive binding-post K to the 135 lamp-frame, carbon-holder, upper and lower carbon, insulated return-wire in one of the side rods, and from there through the part x' of the wire on the main magnet to the negative binding-post. Upon the passage of the 140 current the main magnet is energized and attracts the clamping-armature g , swinging the clamp and gripping the rod by means of the gripping jaws e e . At the same time the armature-lever L is pulled down and the carbons separated. In pulling down the armature 145

both magnets, and therefore as soon as the fine wire is traversed by sufficient current the 165 magnetism of the whole compound magnet is diminished.

With regard to the armature g and the operation of the lamp, the pole m' may be termed as the "clamping" and the pole n' as the "re- 170 leasing" pole.

As the carbons burn away, the fine wire receives more current and the magnetism diminishes in proportion. This causes the armature-lever L to swing and the armature g to 175 descend gradually under the weight of the moving parts until the end p , Fig. 1, strikes a stop on the top plate, B. The adjustment is such that when this takes place the rod R is yet gripped securely by the jaws e e . The further 180 downward movement of the armature-lever being prevented, the arc becomes longer as the carbons are consumed, and the compound magnet is weakened more and more until the clamping-armature g releases the hold 185 of the gripping jaws e e upon the rod R, and the rod is allowed to drop a little, shortening thus the arc. The fine wire now receiving less current, the magnetism increases, and the rod is clamped again and slightly raised, if neces- 190 sary. This clamping and releasing of the rod continues until the carbons are consumed. In practice the feed is so sensitive that for the greatest part of the time the movement of the rod cannot be detected without some actual 195 measurement. During the normal operation of the lamp the armature-lever L remains stationary, or nearly so, in the position shown in Fig. 1.

Should it arise that, owing to an imperfec- 200 tion in the rod, the same and the carbons drop too far, so as to make the arc too short, or even bring the carbons in contact, then a very small amount of current passes through the fine wire, and the compound magnet becomes 205 sufficiently strong to act as on the start in pulling the armature-lever L down and separating the carbons to a greater distance.

It occurs often in practice that the rod sticks in the guides. In this case the arc reaches a 210

THE COMPLETE PATENTS OF NIKOLA TESLA

(No Model.)

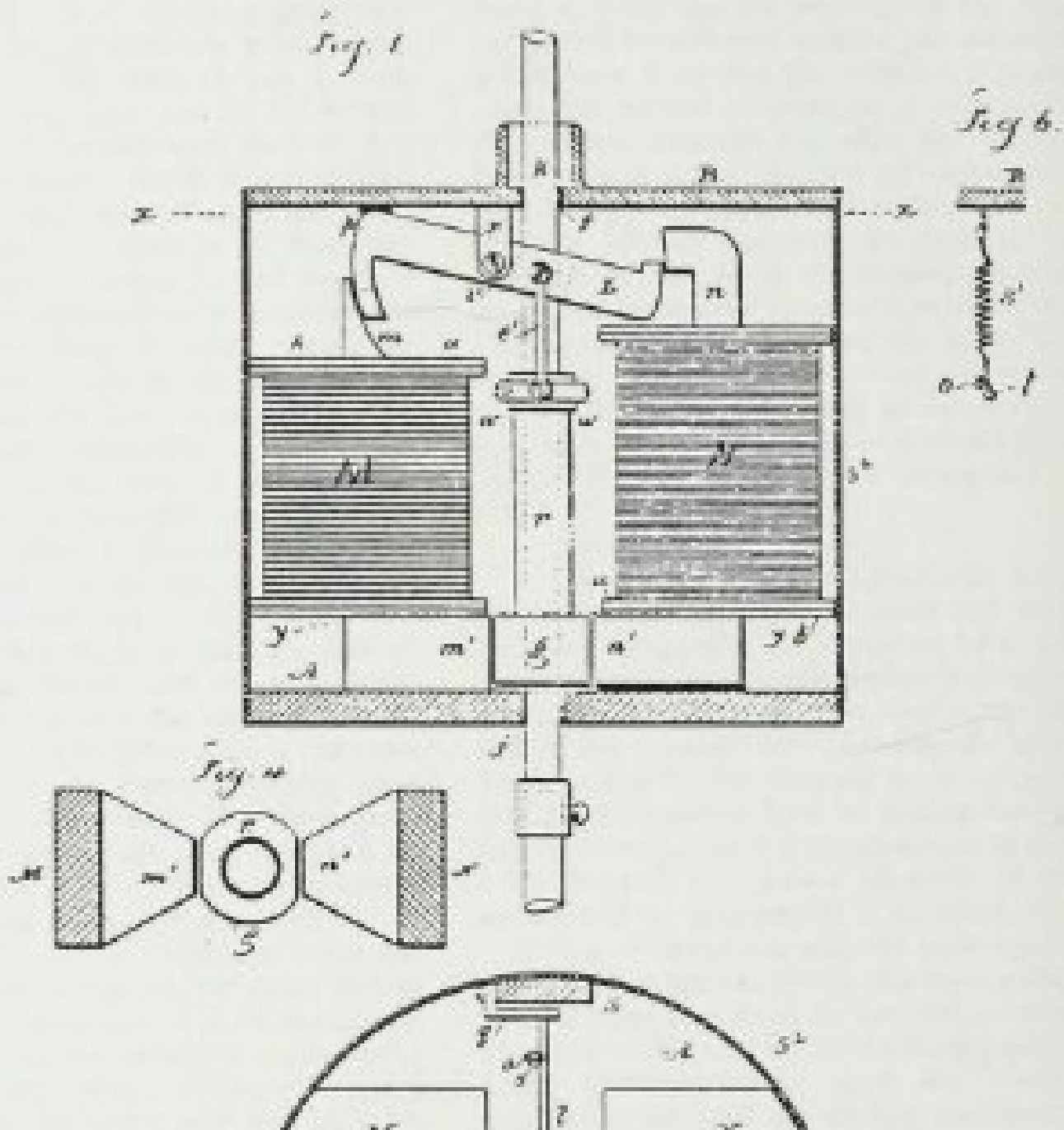
2 Sheets—Sheet 1.

N. TESLA.

ELECTRIC ARC LAMP.

No. 335,787.

Patented Feb. 9, 1886.



THE COMPLETE PATENTS OF NIKOLA TESLA

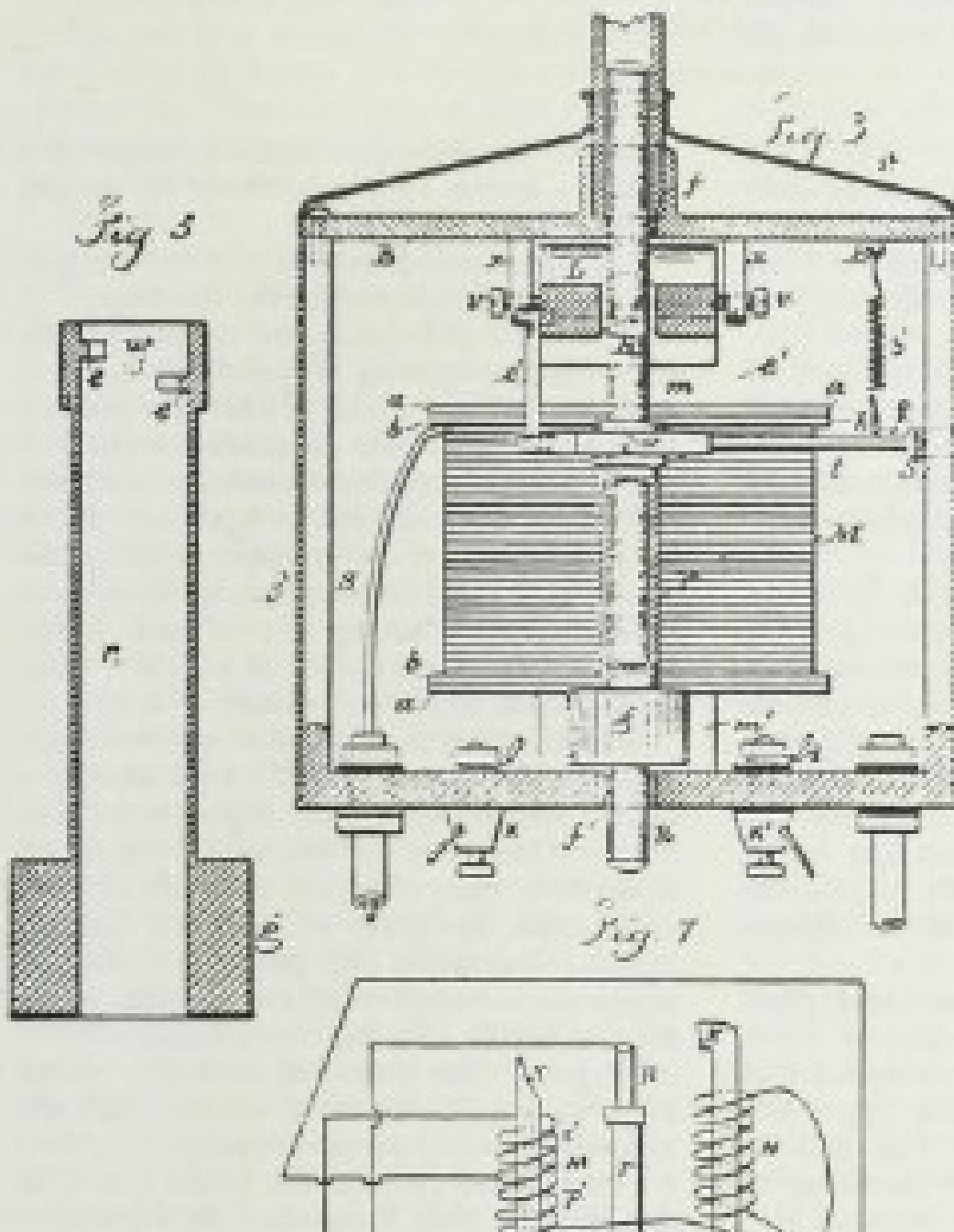
(No Model.)

2 Sheets—Sheet 2.

N. TESLA.
ELECTRIC ARC LAMP.

No. 335,787.

Patented Feb. 9, 1886.



THE COMPLETE PATENTS OF NIKOLA TESLA

THE COMPLETE PATENTS OF NIKOLA TESLA

(No Model.)

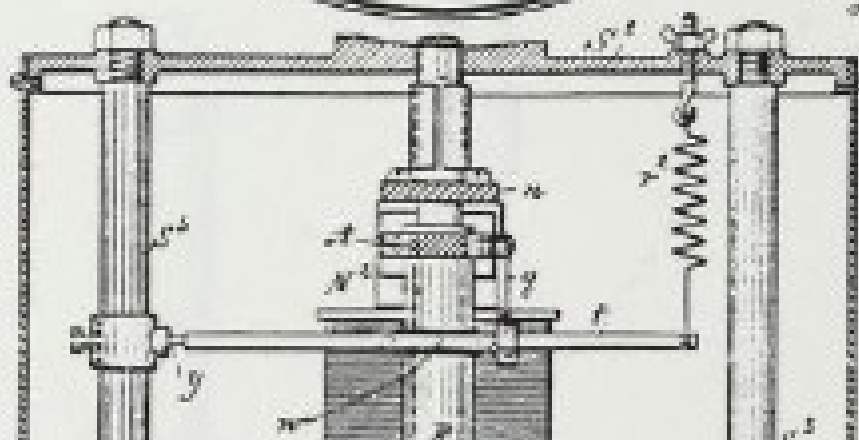
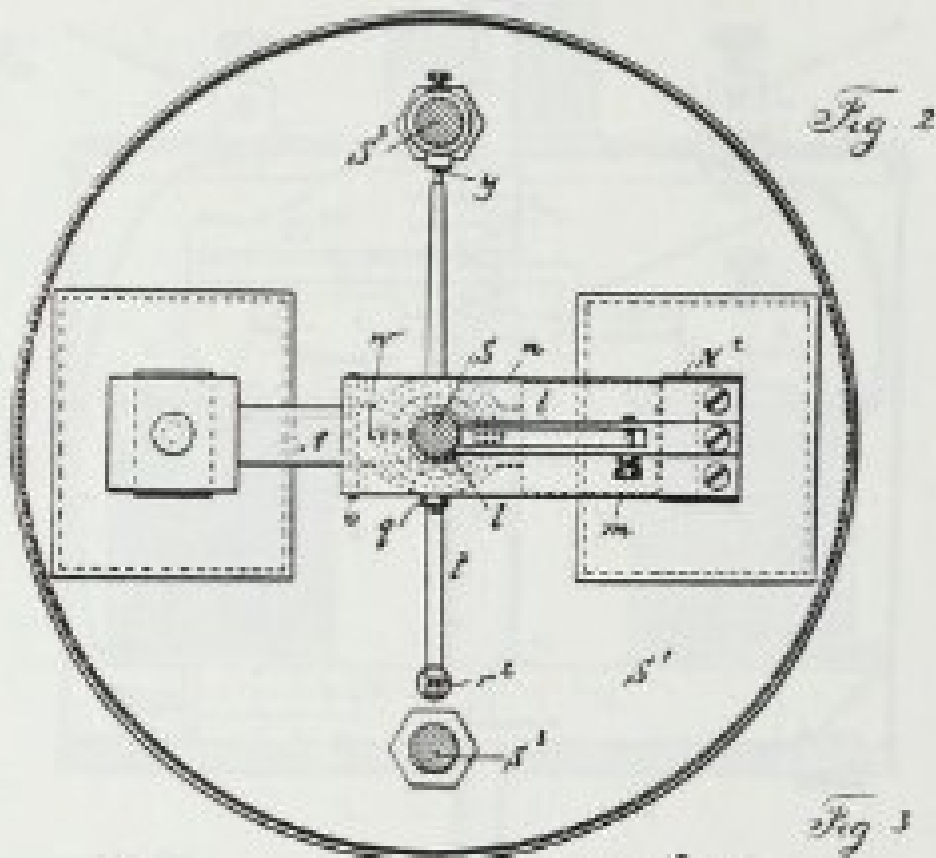
2 Sheets—Sheet 2.

N. TESLA.

ELECTRIC ARC LAMP.

No. 335,786.

Patented Feb. 9, 1886.



THE COMPLETE PATENTS OF NIKOLA TESLA

UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF SMILJAN LIKA, AUSTRIA HUNGARY, ASSIGNOR TO
THE TESLA ELECTRIC LIGHT AND MANUFACTURING COMPANY, OF
RAHWAY, NEW JERSEY.

ELECTRIC-ARC LAMP.

SPECIFICATION forming part of Letters Patent No. 335,786, dated February 9, 1886.

Application filed March 30, 1885. Serial No. 106,574. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, of Smiljan Lika, border country of Austria-Hungary, have invented certain new and useful Improvements in Electric-Arc Lamps of which the following is a specification.

My invention relates more particularly to those arc lamps in which the separation and feed of the carbon electrodes or their equivalents is accomplished by means of electromagnets or solenoids in connection with suitable clutch-mechanism; and it is designed to remedy certain faults common to the greater part of the lamps heretofore made.

The objects of my invention are to prevent the frequent vibrations of the movable electrode and flickering of the light arising therefrom, to prevent the falling into contact of the electrodes, to dispense with the dash-pot, clock-work, or gearing and similar devices heretofore used, and to render the lamp extremely sensitive, and to feed the carbon almost imperceptibly, and thereby obtain a very steady and uniform light.

In that class of lamps where the regulation of the arc is effected by forces acting in opposition on a free movable rod or lever directly connected with the electrode, all or some of the forces being dependent on the strength of the current, any change in the electrical condition of the circuit causes a vibration and a corresponding flicker in the light. This diffi-

objects and to remedy the before-mentioned defects. I combine two electro-magnets—one of low resistance in the main or lamp circuit, and the other of comparatively high resistance in a shunt around the arc—a movable armature-lever, and a novel feed mechanism, the parts being arranged so that in the normal working position of the armature-lever the same is kept almost rigidly in one position, and is not effected even by considerable changes, in the electric circuit; but if the carbons fall into contact the armature will be actuated by the magnets so as to move the lever and start the arc, and hold the carbons until the arc lengthens and the armature-lever returns to the normal position. After this the carbon-rod holder is released by the action of the feed mechanism, so as to feed the carbon and restore the arc to its normal length.

My invention consists, mainly, in the particular manner in which the armature is combined with the magnets and acted upon by them and in the feed-controlling mechanism.

In the drawings, Figure 1 is an elevation of the mechanism made use of in the electric lamp. Fig. 2 is a plan view of the same below the line x x. Fig. 3 is an elevation of the balancing lever and spring, and Fig. 4 is a detached plan view of the pole-pieces and armatures upon the friction-clamp, and Fig. 5 is a section of the clamping-tube.

M is a helix of coarse wire in a circuit from

THE COMPLETE PATENTS OF NIKOLA TESLA

(No Model.)

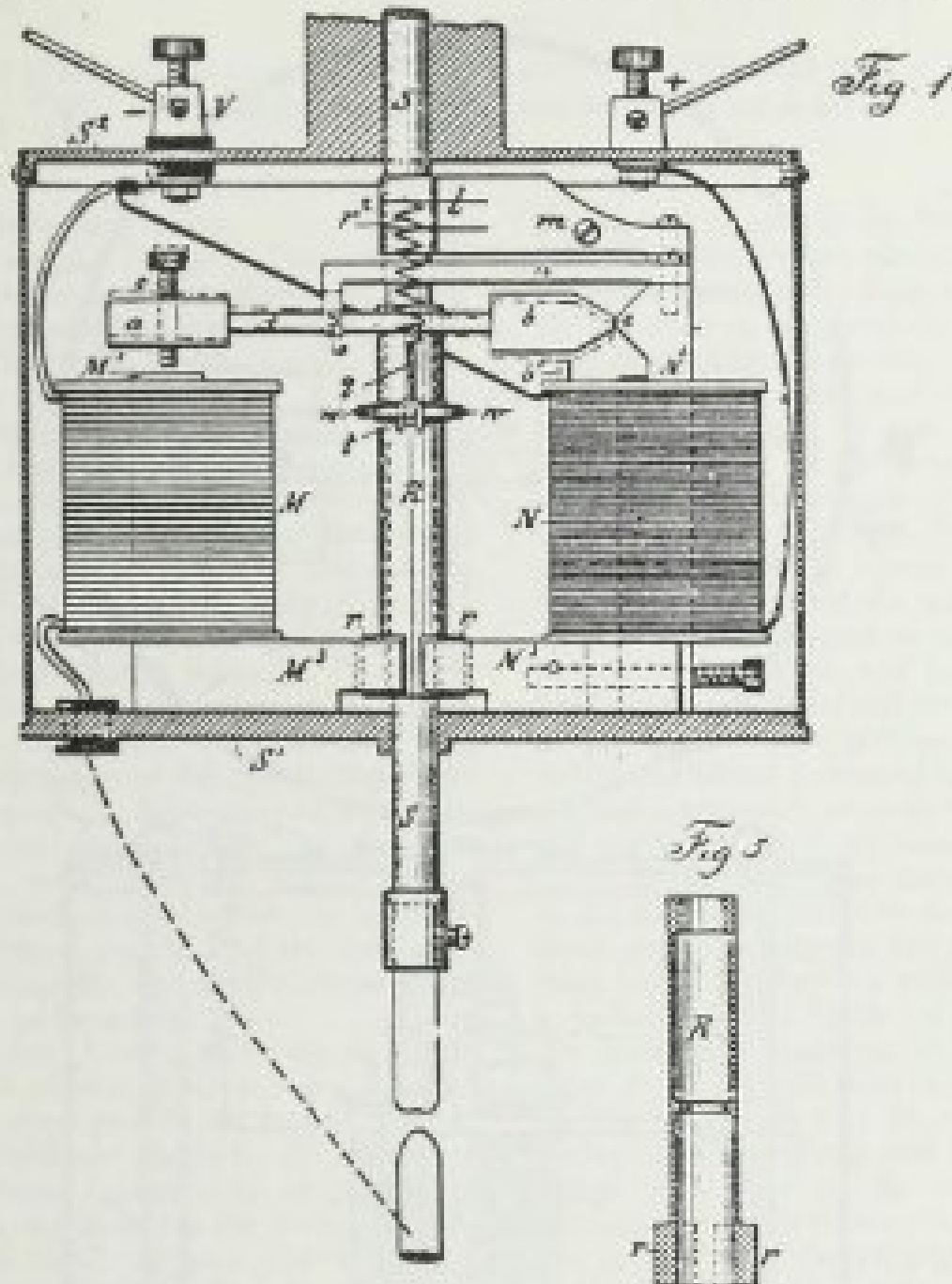
2 Sheets—Sheet 1.

N. TESLA.

ELECTRIC ARC LAMP.

No. 335,786.

Patented Feb. 9, 1886.



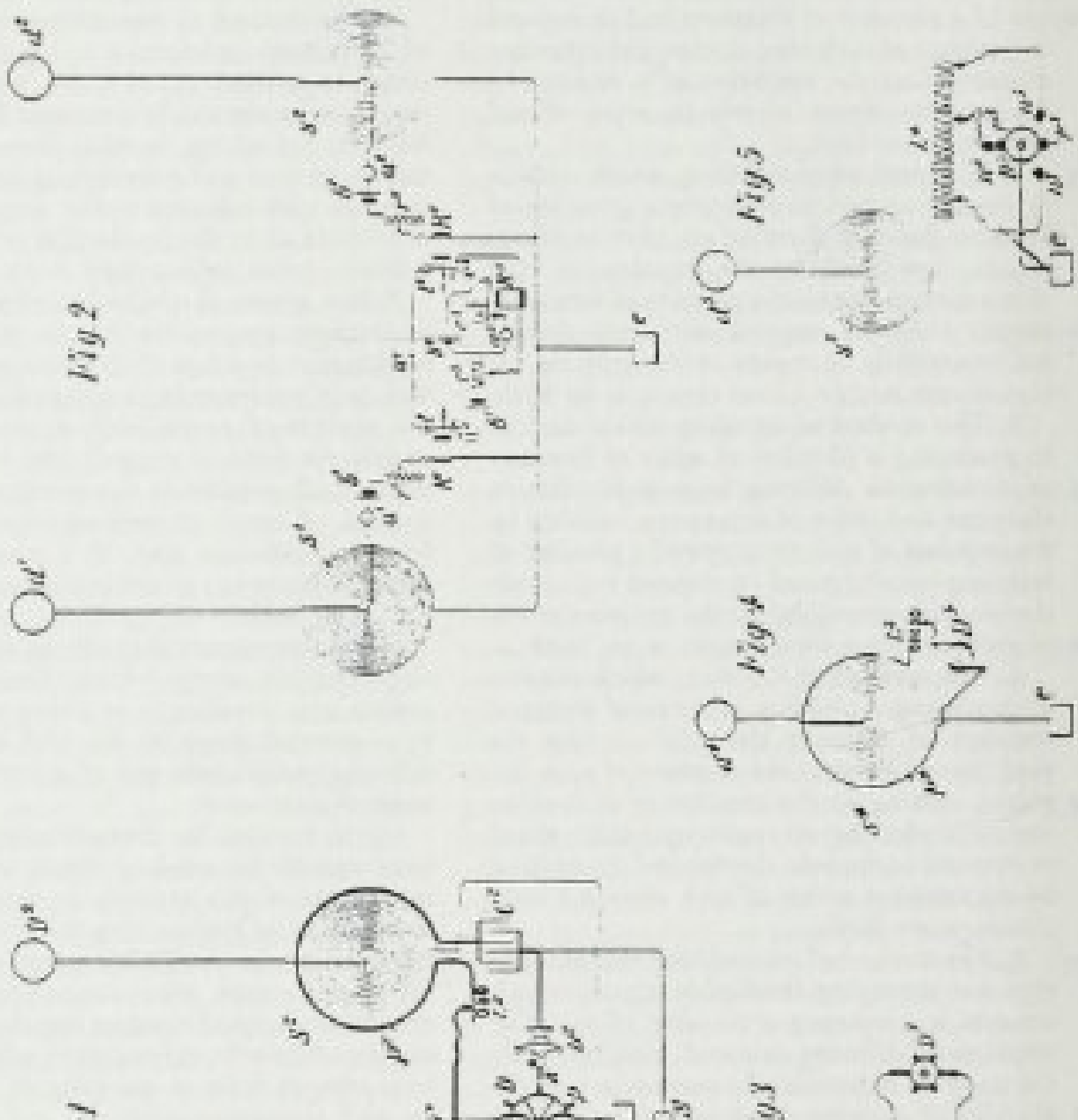
THE COMPLETE PATENTS OF NIKOLA TESLA

No. 725,605.

PATENTED APR. 14 1903.

N. TESLA.
SYSTEM OF SIGNALING.
APPLICATION FILED JULY 18, 1899.

NO MODEL.



THE COMPLETE PATENTS OF NIKOLA TESLA

UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y.

SYSTEM OF SIGNALING.

SPECIFICATION forming part of Letters Patent No. 725,605, dated April 14, 1903,
Application filed July 18, 1900. Serial No. 23,847. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing in the borough of Manhattan, in the city, county, and State of New York, have invented certain new and useful Improvements in Systems of Signaling, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

In certain systems for transmitting intelligible messages or governing the movements and operations of distant automata electrical impulses or disturbances produced by suitable apparatus are conveyed through the natural media to a distant receiving-circuit capable of responding to the impulses, and thereby effecting the control of other appliances. Generally a special device highly sensitive is connected to the receiving-circuit, which in order to render it still more susceptible and to reduce the liability of its being affected by extraneous disturbances is carefully adjusted so as to be in tune with the transmitter. By a scientific design of the sending and receiving circuits and other apparatus and skillful adjustment of the same these objects may be in a measure attained; but in long experience I have found that notwithstanding all constructive advantages and experimental resources this method is in many cases inadequate. Thus while I have succeeded in so operating selectively under certain favorable conditions more than one hundred receivers in most cases it is

is derived from tuning the circuits. It being an imperative requirement in most practical applications of such systems of signaling or intelligence transmission that the signals or messages should be exclusive or private, it is highly desirable to do away with the above limitations, especially in view of the fact, which I have observed, that the influence of powerful electrical disturbances upon sensitive receivers extends, even on land, to distances of many hundreds of miles, and consequently in accordance with theory still farther on sea. To overcome these drawbacks and to enable a great number of transmitting and receiving stations to be operated selectively and exclusively and without any danger of the signals or messages being disturbed, intercepted, or interfered with in any way is the object of my present invention.

Broadly stated, this invention consists in the combination of means for generating and transmitting two or more kinds or classes of disturbances or impulses of distinctive character with respect to their effect upon a receiving-circuit and a distant receiver which comprises two or more circuits of different electrical character or severally tuned, so as to be responsive to the different kinds or classes of impulses and which is dependent for operation upon the conjoint or resultant action of the two or more circuits or the several instrumentalities controlled or operated thereby. By employing only two kinds of disturbances or

THE COMPLETE PATENTS OF NIKOLA TESLA

being emitted simultaneously or in rapid suc-
230 cession, as may be desired, at each closure of
the circuit. The two receiving-circuits at the
distant station, each tuned to respond to the
vibrations produced by one of the elements of
the transmitter, affect the sensitive devices a'
235 and a'' and cause the relays R' and R'' to be
operated and contacts c' and c'' to be closed,
thus actuating the receiver or relay R^1 , which
in turn establishes a contact c^1 and brings into
action a device a^1 by means of a battery d^1 ,
240 included in a local circuit, as shown. But evi-
dently if through any extraneous disturbance
only one of the circuits at the receiving-station
is affected the relay R^1 will fail to respond. In
this way a communication may be carried on
245 with greatly-increased safety against inter-
ference and privacy of the messages may be se-
cured. The receiving-station shown in Fig. 2
is supposed to be one requiring no return mes-
sage; but if the use of the system is such that
250 this is necessary then the two stations will be
similarly equipped, and any well-known means,
which it is not thought necessary to illustrate
here, may be resorted to for enabling the appa-
ratus at each station to be used in turn as
255 transmitter and receiver. In like manner the
operation of a receiver, as R^1 , may be made
dependent instead of upon two upon more
than two such transmitting systems or circuits,
and thus any desired degree of exclusiveness
260 or privacy and safety against extraneous dis-
turbances may be attained. The apparatus as illu-
strated in Figs. 1 and 2 permits, however,
special results to be secured by the adjustment
of the order of succession of the discharges of
the primary circuits P' and P'' or of the time
265 intervals between such discharges. To illus-
trate: The action of the relays R' R'' may be
regulated either by adjusting the weights of
the levers l' l'' , or the strength of the batteries
 b' b'' , or the resistances r' r'' , or in other well-
known ways, so that when a certain order of
270 succession or time interval between the dis-
charges of the primary circuits P' and P'' exists
at the sending-station the levers l' and l'' will
275 close the contacts c' and c'' at the same instant,
and thus operate the relay R^1 , but will fail to
produce this result when the order of suc-

cession of waves or impulses of different 295
characteristics may be produced by an instru-
ment having but one such circuit. A few of
the many ways which will readily suggest
themselves to the expert who applies my in-
vention are illustrated in Figs. 3, 4, and 5. In 300
Fig. 3 a transmitting system e s^1 d^1 is partly
shunted by a rotating wheel or disk D^1 , which
may be similar to that illustrated in Fig. 1 and
which cuts out periodically a portion of the
coil or conductor s^1 , or, if desired, bridges it 305
by an adjustable condenser C^1 , thus altering
the vibration of the system e s^1 d^1 at suitable
intervals and causing two distinct kinds or
classes of impulses to be emitted in rapid suc-
cession by the sender. In Fig. 4 a similar result 310
is produced in the system e s^1 d^1 by periodi-
cally short-circuiting, through an induction-
coil L^1 and a rotating disk D^1 with insulating
and conducting segments, a circuit p^1 in in-
ductive relation to said system. Again, in Fig. 315
5 three distinct vibrations are caused to be
emitted by a system e s^1 d^1 , this result being
produced by inserting periodically a number
of turns of an induction-coil L^1 in series with
the oscillating system by means of a rotating 320
disk B^1 with two projections p^1 p^2 and three
rods or brushes a^1 , placed at an angle of one
hundred and twenty degrees relatively to each
other. The three transmitting systems or cir-
cuits thus produced may be energized in the 325
same manner as those of Fig. 1 or in any other
convenient way. Corresponding to each of
these cases the receiving-station may be pro-
vided with two or three circuits in an analo-
gous manner to that illustrated in Fig. 2, it 330
being understood, of course, that the different
vibrations or disturbances emitted by the
sender follow in such rapid succession upon
each other that they are practically simultane-
ous so far as the operation of such relays as 335
 R' and R'' is concerned. Evidently, however,
it is not necessary to employ two or more
receiving-circuits, but a single circuit may be
used also at the receiving-station constructed
and arranged like the transmitting-circuits or 340
systems illustrated in Figs. 3, 4, and 5, in
which case the corresponding disks, as D^1 D^2
 D^3 , at the sending will be driven in synchron-

THE COMPLETE PATENTS OF NIKOLA TESLA

transmission of the impulses is effected
360 through natural media, but for the transmission of energy for any purpose and whatever the medium through which the impulses are conveyed.

What I claim is—

365 1. The method of operating distant receivers which consists in producing and transmitting a plurality of kinds or classes of electrical impulses or disturbances, actuating by the impulses or disturbances of each kind or class
370 one of a plurality of circuits tuned to respond to impulses of such kind or class and operating or controlling the operation of a receiver by the conjoint action of two or more of said circuits, as set forth.

375 2. The method of signaling, which consists in producing and transmitting a plurality of kinds or classes of electrical impulses or disturbances, developing by the impulses of each class a current in one of a plurality of receiving-
380 circuits tuned to respond exclusively thereto and controlling by means of the conjoint action of such circuits a local circuit, as set forth.

3. The method of signaling which consists in producing a plurality of series of impulses
385 or disturbances differing from each other in character and order of succession, exciting by the impulses of each series one of a plurality of receiving-circuits tuned to respond exclusively thereto and controlling by the conjoint action
390 of such circuits a local circuit, as set forth.

4. The method of signaling which consists in producing a plurality of series of electrical impulses of different character, varying the
395 time interval between the emission of such impulses, exciting by the impulses of each series one of a plurality of receiving-circuits tuned to respond exclusively thereto and controlling by the conjoint action of such circuits a local circuit, as set forth.

400 5. The method of transmitting electrical energy for conveying intelligible signals which consists in producing a plurality of electrical impulses of different character, developing by the impulses of each kind a current in one of a
405 plurality of receiving-circuits tuned to respond exclusively thereto, controlling the action or effect of the transmitted impulses upon the receiving-circuits by varying the character of

6. The method of transmitting electrical energy which consists in producing a plurality of electrical waves or impulses of different pe- 415
riodicities, varying the order of transmission of the waves or impulses forming elements of the signal sent, according as one or another receiving-station is to be communicated with where (proper circuit-closing mechanism being 420
provided at each receiving-station) the transmitted signal will be intelligible at and only at the intended receiving-station.

7. The method of transmitting intelligence, which consists in selecting and associating to- 425
gether in predetermined order of succession two or more electrically-generated impulses of different periodicity, forming elements of signals to be sent, and transmitting such selected impulses with reference to the conjoint action 430
of both or all in the production of a signal at a distant point, substantially as set forth.

8. In a system of telegraphy, wherein signals or messages are sent by the use of a plurality of electrical impulses of different periodicities 435
and in a predetermined order of succession, the method of ascertaining at any particular station the particular signal sent to that station, which consists in the selection, to form a signal, of certain transmitted impulses of dif- 440
ferent periodicities and of a predetermined order of succession to the exclusion of all others, as set forth.

9. The improvement in the art of transmitting electrical energy which consists in op- 445
erating or controlling a receiving mechanism by a series or group of electrical impulses of different periodicities and of a predetermined order of succession.

10. In a system for the transmission of elec- 450
trical energy, for sending signals or messages to any one of two or more receiving-stations, the method of transmitting the message with reference to the intelligible receipt thereof at the desired station, which consists in the trans- 455
mission of electrical waves or impulses of different periodicities in varying order of transmittal by a separate order or grouping of transmittal for each receiving-station.

NIKOLA TESLA.

Witnesses

THE COMPLETE PATENTS OF NIKOLA TESLA

UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y.

METHOD OF SIGNALING.

SPECIFICATION forming part of Letters Patent No. 723,188, dated March 17, 1903.
Original application filed July 16, 1900, Serial No. 23,847. Divided and this application filed June 14, 1901.
Serial No. 66,322. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing in the borough of Manhattan, in the city, county, and State of New York, have invented certain new and useful Improvements in Methods of Signaling, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

In certain systems for transmitting intelligible messages or governing the movements and operations of distant automata electrical impulses or disturbances produced by suitable apparatus are conveyed through the natural media to a receiving-circuit capable of responding to the impulses, and thereby effecting the control of other appliances. Generally a special device, highly sensitive, is connected to the receiving-circuit, which in order to render it still more susceptible and to reduce the liability of its being affected by extraneous disturbances is carefully adjusted so as to be in tune with the transmitter. By a scientific design of the sending and receiving circuits and other apparatus and skilful adjustment of the same these objects may be in a measure attained; but in long experience I have found that notwithstanding all constructive advantages and experimental resources this method is in many cases inadequate. Thus while I have succeeded in so operating selectively under certain favorable conditions more than one

be derived from tuning the circuits. It being an imperative requirement in most practical applications of such systems of signaling or intelligence transmission that the signals or messages should be exclusive or private, it is highly desirable to do away with the above limitations, especially in view of the fact which I have observed that the influence of powerful electrical disturbances upon sensitive receivers extends even on land to distances of many hundreds of miles, and consequently, in accordance with theory, still farther on sea. To overcome these drawbacks and to enable a great number of transmitting and receiving stations to be operated selectively and exclusively and without any danger of the signals or messages being disturbed, intercepted, or interfered with in any way is the object of my present invention.

Broadly stated, this invention consists in generating two or more kinds or classes of disturbances or impulses of distinctive character with respect to their effect upon a receiving-circuit and operating thereby a distant receiver which comprises two or more circuits, each of which is tuned to respond exclusively to the disturbances or impulses of one kind or class and so arranged that the operation of the receiver is dependent upon their conjoint or resultant action.

By employing only two kinds of disturbances or series of impulses instead of one, as

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turbances or series of impulses, but also by
100 judicious choice of the same and order in
which they are made to act upon the receiver.

Evidently there are a great many ways of
generating impulses or disturbances at any
wave length, wave form, number or order of
105 succession, or of any special character, such as
will be capable of fulfilling the requirements
above stated, and there are also many ways in
which such impulses or disturbances may be
made to cooperate and to cause the receiver
110 to be actuated, and inasmuch as the skill and
practical knowledge in these novel fields can
only be acquired by long experience the degree
of safety and perfection attained will necessar-
ily depend upon the ability and resource of
115 the expert who applies my invention; but in
order to enable the same to be successfully
practiced by any person possessed only of the
more general knowledge and experience in
these branches I shall describe the simplest
120 plan of carrying it out which is at present
known to me.

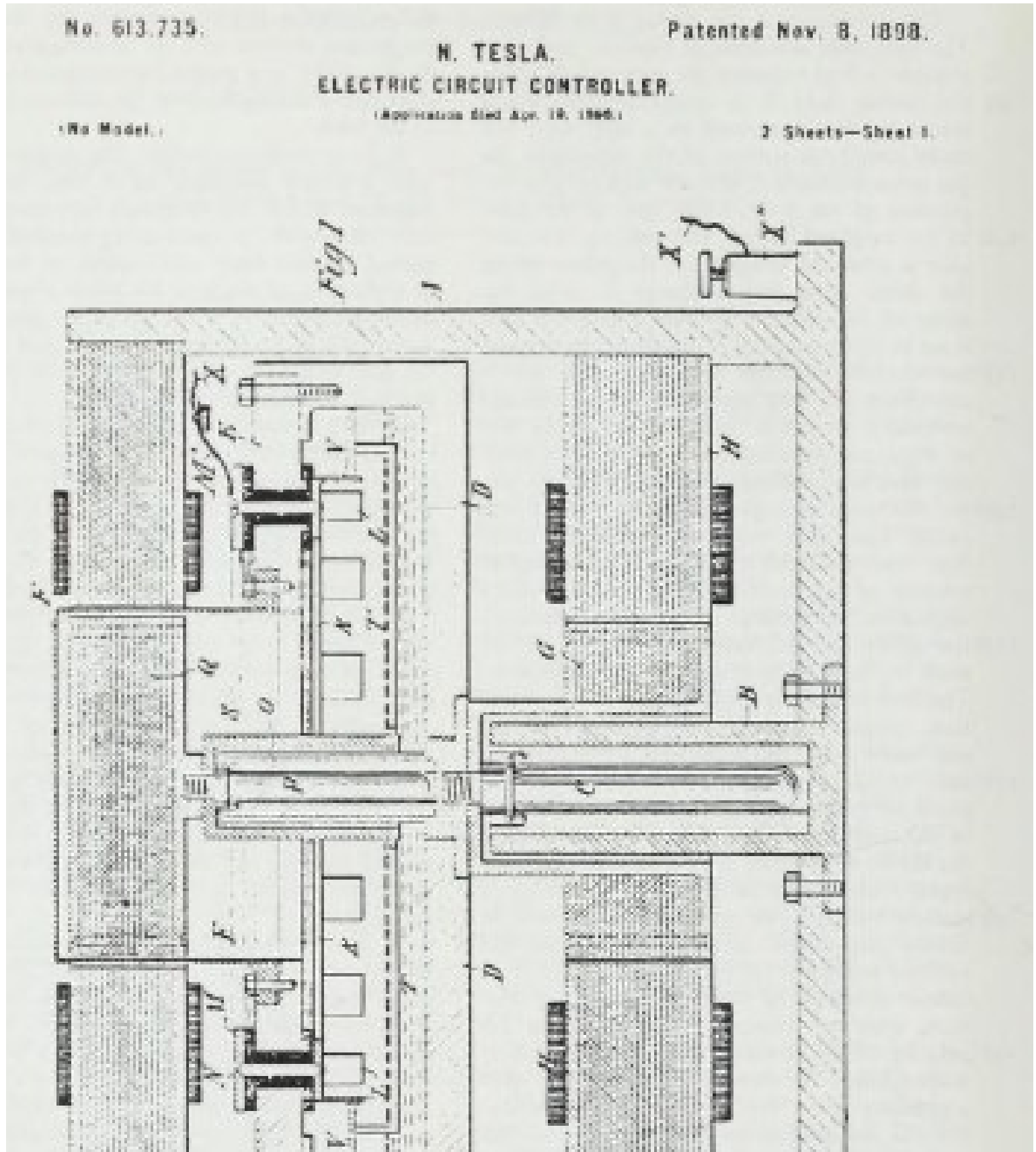
For a better understanding of the subject
reference is now made to the accompanying
drawings, in which—

125 Figures 1 and 2 represent diagrammatically
an apparatus and circuit connections em-
ployed at the sending and receiving stations,
respectively, for the practice of my invention;
and Figs. 3, 4, and 5, modified means which
130 may be employed in the practical application
of the invention.

In Fig. 1, $S^1 S^2$ are two spirally-wound coils
or conductors connected with their inner ends
to preferably elevated terminals D^1 and D^2 ,
135 respectively, and with their outer ends to an
earth-plate E . These two coils, conductors, or
systems $D^1 S^1 E$ and $D^2 S^2 E$ have different
and suitably-chosen periods of vibration, and,
as pointed out in other patents relating to my
140 system of energy and intelligence transmission,
their lengths should be such that the points of
maximum pressure developed therein coincide
with the elevated terminals $D^1 D^2$. By suitably-
chosen periods of vibration such periods are
145 meant as will secure the greatest safety against
interference, both mutual and extraneous. The
two systems may have electrical oscillations

are so adjusted that each primary is in close
resonance with its secondary system, as I have 165
explained in other patents granted to me. The
brush-holders B^1 and B^2 are capable independ-
ently of angular and, if necessary, also of lat-
eral adjustment, so that any desired order of
succession or any difference of time interval 170
between the discharges occurring in the two
primary circuits may be obtained. The con-
densers being energized from a suitable source
 S , preferably of high potential, and the disk
 D being rotated, its projections or teeth $p p$ 175
coming at periodically-recurring intervals in
very close proximity to or, as the case may be,
in contact with conducting rods or brushes n
 n cause the condensers to be discharged in
rapid succession through their respective cir- 180
cuits. In this manner the two secondary sys-
tems $D^1 S^1 E$ and $D^2 S^2 E$ are set in vibration
and oscillate freely each at its proper rate for
a certain period of time at every discharge.
The two vibrations are impressed upon the 185
ground through the plate E and spread to a
distance reaching the receiving-station, which
has two similar circuits or systems $r^1 s^1 d^1$ and
 $r^2 s^2 d^2$, arranged and connected in the same
manner and tuned to the systems at the send- 190
ing-station, so that each responds exclusively
to one of the two vibrations produced by the
transmitting apparatus. The same rules of ad-
justment are observed with respect to the re-
ceiving-circuits, care being furthermore taken 195
that the tuning is effected when all the appar-
atus is connected to the circuits and placed in
position, as any change may more or less mod-
ify the vibration. Each of the receiving-coils s^1
and s^2 is shunted by a local circuit containing, 200
respectively, sensitive devices $a^1 a^2$, batteries b^1
 b^2 , adjustable resistances $r^1 r^2$, and sensitive re-
lays $R^1 R^2$, all joined in series, as shown. The
precise connections and arrangements of the
various receiving instruments are largely im- 205
material and may be varied in many ways. The
sensitive devices $a^1 a^2$ may be any of the well-
known devices of this kind—as, for example,
two conducting-terminals separated by a mi-
nute air-gap or a thin film of dielectric which 210
is strained or weakened by a battery or other
means to the point of breaking down and

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No. 613,735

Patented Nov. 8, 1898.

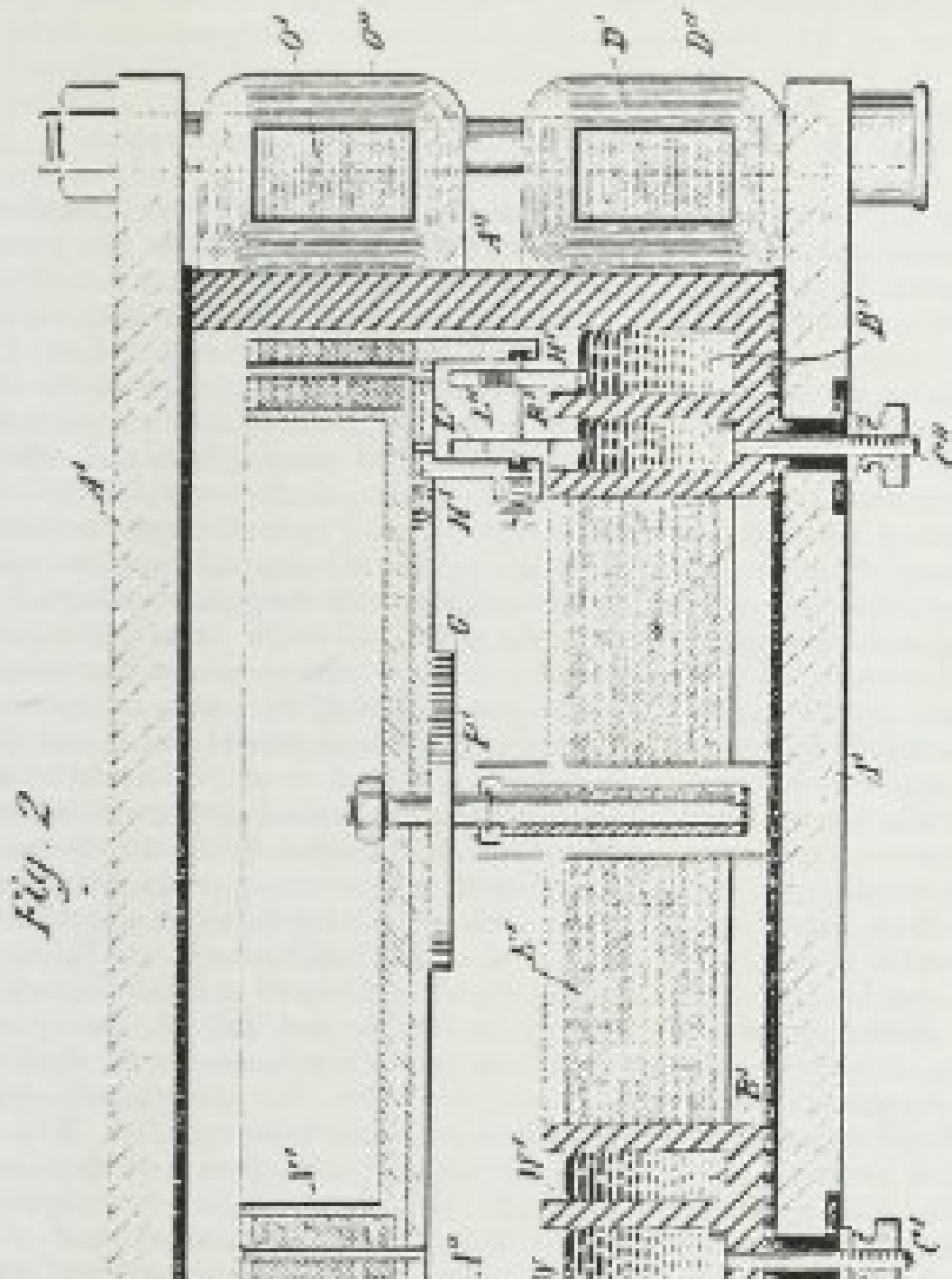
N. TESLA.

ELECTRIC CIRCUIT CONTROLLER.

Application filed Apr. 28, 1898.

(No Model.)

2 Sheets - Sheet 2.



THE COMPLETE PATENTS OF NIKOLA TESLA

NIKOLA TESLA, OF NEW YORK, N.Y.

ELECTRIC-CIRCUIT CONTROLLER.

SPECIFICATION forming part of Letters Patent No. 609,247, dated August 16, 1898.

Application filed March 12, 1898. Serial No. 673,558. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, of the borough of Manhattan, in the city, county, and State of New York, have invented certain new and useful Improvements in Circuit-Controllers, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

In an application filed by me on June 3, 1897, Serial No. 639,227, I have shown and described a device for making and breaking an electric circuit comprising a rotary receptacle containing a conducting fluid and a terminal mounted within but independently of the receptacle and caused by the rotation of the latter to make and break electrical contact with the fluid.

The invention on which my present application is based is an improvement in devices of this particular class, and has primarily as its object the production of a circuit-controller in which an independently-mounted terminal operated in a similar manner by a rotating body of conducting fluid may be inclosed within a gas-tight receptacle.

The invention comprises features of construction by which this object is practically secured and certain improvements applicable to this and other analogous devices, as will be more fully hereinafter set forth.

In the accompanying drawings, Figure 1 is vertical central section of the improved circuit-controller, and Fig. 2 a top plan view of the same with the top or cover of the receptacle removed.

The operative portions of the circuit-controlling mechanism are contained in a

brushes I, these parts being arranged to constitute an electromagnetic motor with stationary field and rotating armature. It may be stated that any other suitable means may be employed to rotate the receptacle and the fluid.

In the spindle B and concentric with its axis is a spindle J in bearings specially constructed to reduce friction in order that the spindle J may be as little as possible influenced by the rotation of the main spindle and receptacle carried thereby. A suitable provision is made to oppose or prevent the rotation of the spindle J during the rotation of the receptacle. I have devised for this purpose the following:

The spindle B is held by its bearings at an angle to the vertical, and a weight K is secured eccentrically to the spindle J and tends to hold the said spindle always in one position. The inclination of the axes of rotation necessary for this result may be substantially that shown and should not be materially greater, for the reason that it is especially advantageous to preserve the spindles and bearings as nearly as practicable vertical on account of lesser friction and easier lubrication.

Attached to the spindle J or weight K is an insulated bracket L, carrying a standard or socket M, in which is mounted on antifriction-bearings a spindle N. Secured to this latter is a plate with radial arms O, from which depend vanes or blades P, with projections Q extending radially therefrom. A shield or screen R incloses the vanes, except on the side adjacent to the inner periphery of the receptacle A.

A small quantity of a conducting fluid S is placed in the receptacle, and in order to secure

THE COMPLETE PATENTS OF NIKOLA TESLA

To operate the apparatus, the receptacle is set in rotation, and as its speed increases the mercury or other conducting fluid which it contains is carried by centrifugal force up the sides of the inner wall, over which it spreads in a layer. When this layer rises sufficiently to encounter the projections Q on the blades or vanes P, the latter are set in rapid rotation, and the electrical connection between the terminal of the apparatus is thereby made and broken, it may be, with very great rapidity.

The projections Q are preferably placed at different heights on the vanes P, so as to secure greater certainty of good contact with the mercury film when in rapid rotation.

As to the forms of the circuit-controller heretofore referred to and upon which my present invention is an improvement the blades or vanes P may be regarded in a broad sense as typical of any device—such, for example, as a stelliform disk—which will be set and maintained in rotation by that of the receptacle. So, also, having regard to the feature of my invention which provides for maintaining such a device in operation in a receptacle which may be hermetically sealed, so as to be capable of containing an inert medium under pressure in which the makes and breaks occur and which medium is practically essential to a long-continued and economical operation of the device, I may employ other and widely-different means for opposing or preventing the rotation of the part carrying such vanes in the direction of the rotation of the receptacle and fluid.

Having now described my invention, what I claim is—

1. A circuit-controller comprising, in combination, a closed receptacle containing a fluid, means for rotating the receptacle, a support mounted within the receptacle, means for opposing or preventing its movement in the direction of rotation of the receptacle, and a conductor carried by said support and adapted to make and break

combination, a terminal capable of rotation and formed or provided with radiating contacts, a closed receptacle containing a fluid which constitutes the opposite terminal, means for rotating the receptacle, a support therein for the rotating terminal, and means for opposing or preventing the rotation of the support in the direction of the rotation of the receptacle, as set forth.

3. In a circuit-controller, the combination with a receptacle capable of rotation about an axis inclined to the vertical and containing a fluid which constitutes one terminal, a second terminal mounted within the receptacle, on a support capable of free rotation relatively to the receptacle, and a weight eccentric to the axis of rotation of the support for said terminal for opposing or preventing its movement in the direction of the rotation of the said receptacle, as set forth.

4. The combination with a receptacle mounted to revolve about an axis inclined to the vertical, of a spindle within the receptacle and concentric with its axis, a weight eccentric to the spindle, and a terminal carried by the said spindle, and adapted to be rotated by a body of conducting fluid contained in the receptacle when the latter is rotated, as set forth.

5. The combination with a receptacle mounted to rotate about an axis inclined to the vertical, a spindle within the receptacle and concentric with its axis, a weighted arm attached to said spindle, a bracket or arm also secured to said spindle, a rotary terminal with radiating contact arms or vanes mounted on said bracket in position to be rotated by a body of conducting fluid contained in said receptacle when said fluid is displaced by centrifugal action, as set forth.

NIKOLA TESLA.

Witnesses:

M. LAWSON DYER,
G. W. MARTLING.

THE COMPLETE PATENTS OF NIKOLA TESLA

sages to nozzles fixed to the rotating receptacle and adapted to discharge across the path of the jet from the stationary nozzle, as set forth.

235 6. In a circuit-controller the combination with a rotating receptacle of a body mounted therein and formed or provide with a weighted portion eccentric to its axis which opposes its rotation and a tube or duct carried by said
240 body and adapted to take up a conducting fluid from the rotating receptacle as set forth.

7. In a circuit-controller the combination of two sets of nozzles and means for projecting

tively to each other so that the jets of the two sets are brought successively into contact, the nozzles of each set being arranged symmetrically about an axis of rotation, there being one 250 more nozzle in one set than in the other.

NIKOLA TESLA.

Witnesses:

M. LAWSON DYER,
G. W. MARTLING,

THE COMPLETE PATENTS OF NIKOLA TESLA

No. 609,247.

Patented Aug. 16, 1898.

N. TESLA. ELECTRIC CIRCUIT CONTROLLER.

(Application filed Mar. 17, 1898.)

(No Model.)

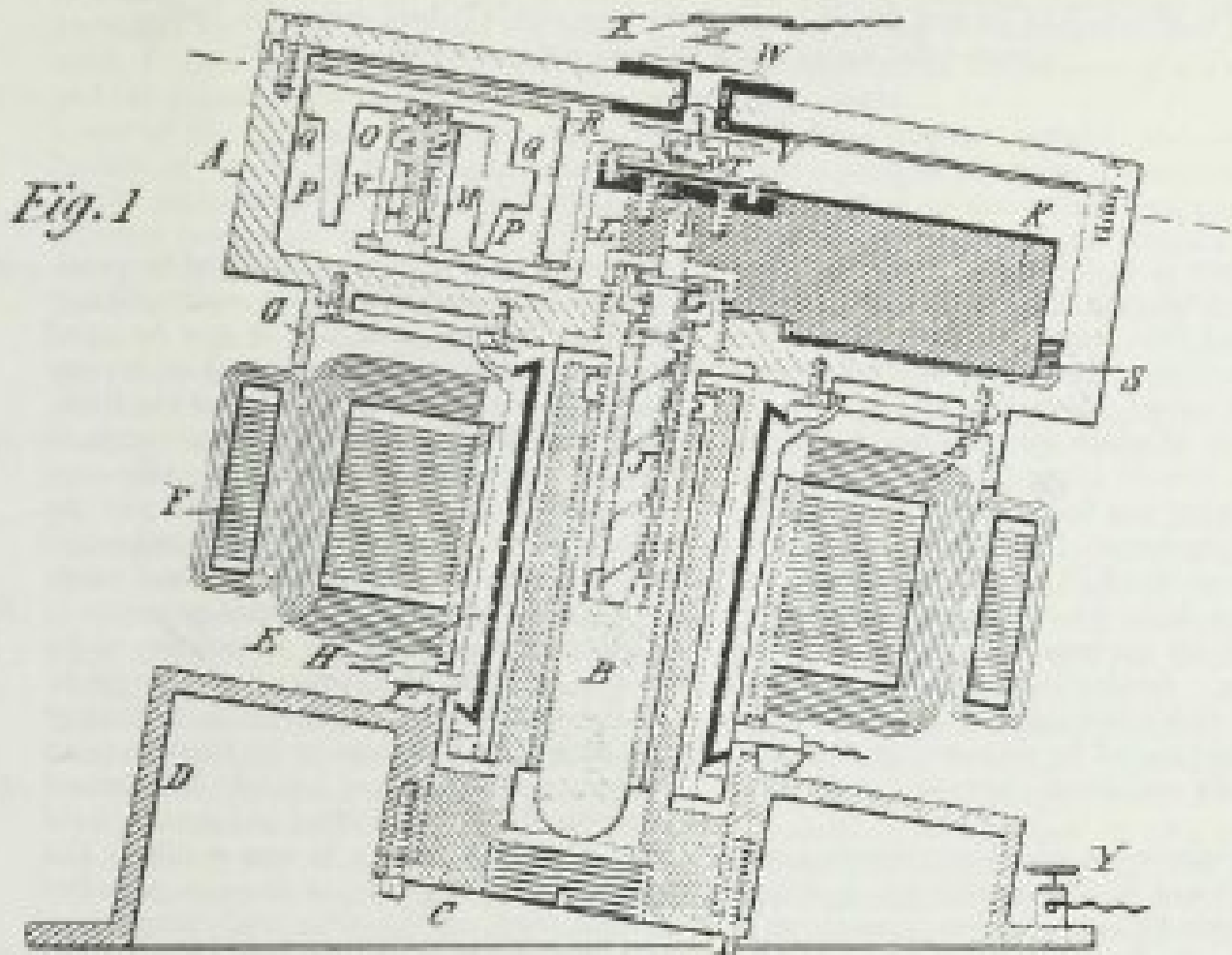
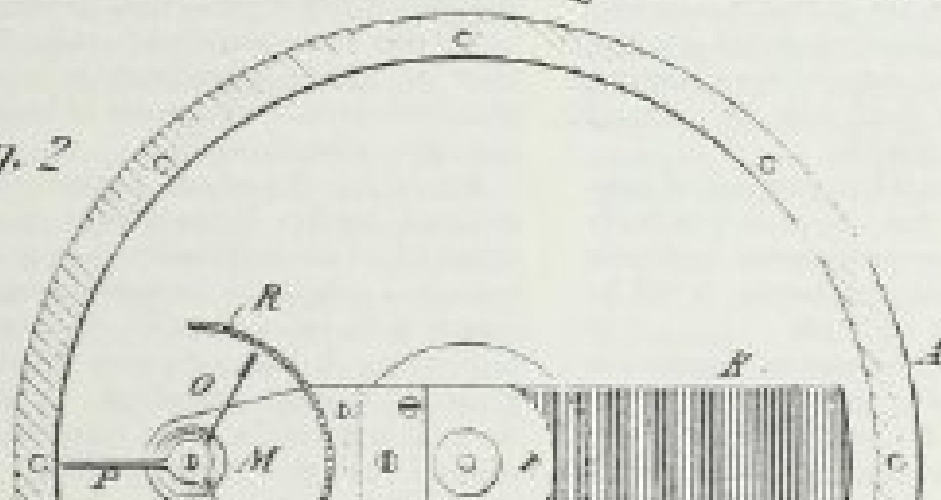


Fig. 2



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363 taining a conducting fluid, of a conductor mounted within the receptacle, means for rotating the same, a screw rotating with the conductor and extending into a well in which the fluid collects, and a duct or ducts leading from the well to points from which the fluid will be directed against the rotating conductor.

370 10. The combination with the receptacle, of a spindle secured to its head or cover, a magnetic core mounted on the spindle within

and operating to maintain a jet or jets of conducting fluid, against the conductor when in rotation. 375

NIKOLA TESLA.

Witnesses:

M. LAWSON DYER,

G. W. MARTLING.

THE COMPLETE PATENTS OF NIKOLA TESLA

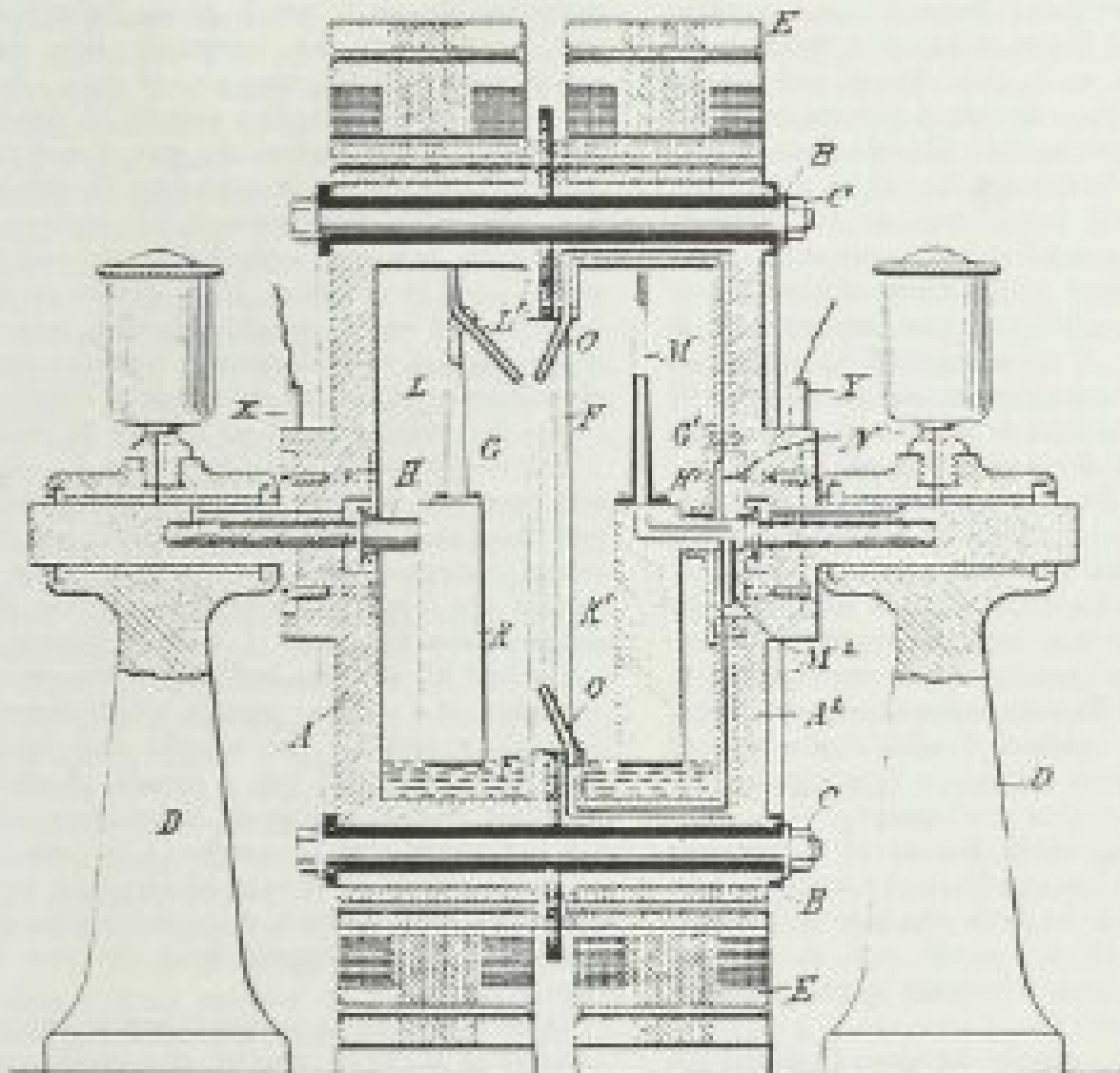
No. 609,246.

Patented Aug. 16, 1898.

N. TESLA.
ELECTRIC CIRCUIT CONTROLLER.

(Application filed Feb. 28, 1896.)

(No Model.)



THE COMPLETE PATENTS OF NIKOLA TESLA

THE COMPLETE PATENTS OF NIKOLA TESLA

No. 611,719.

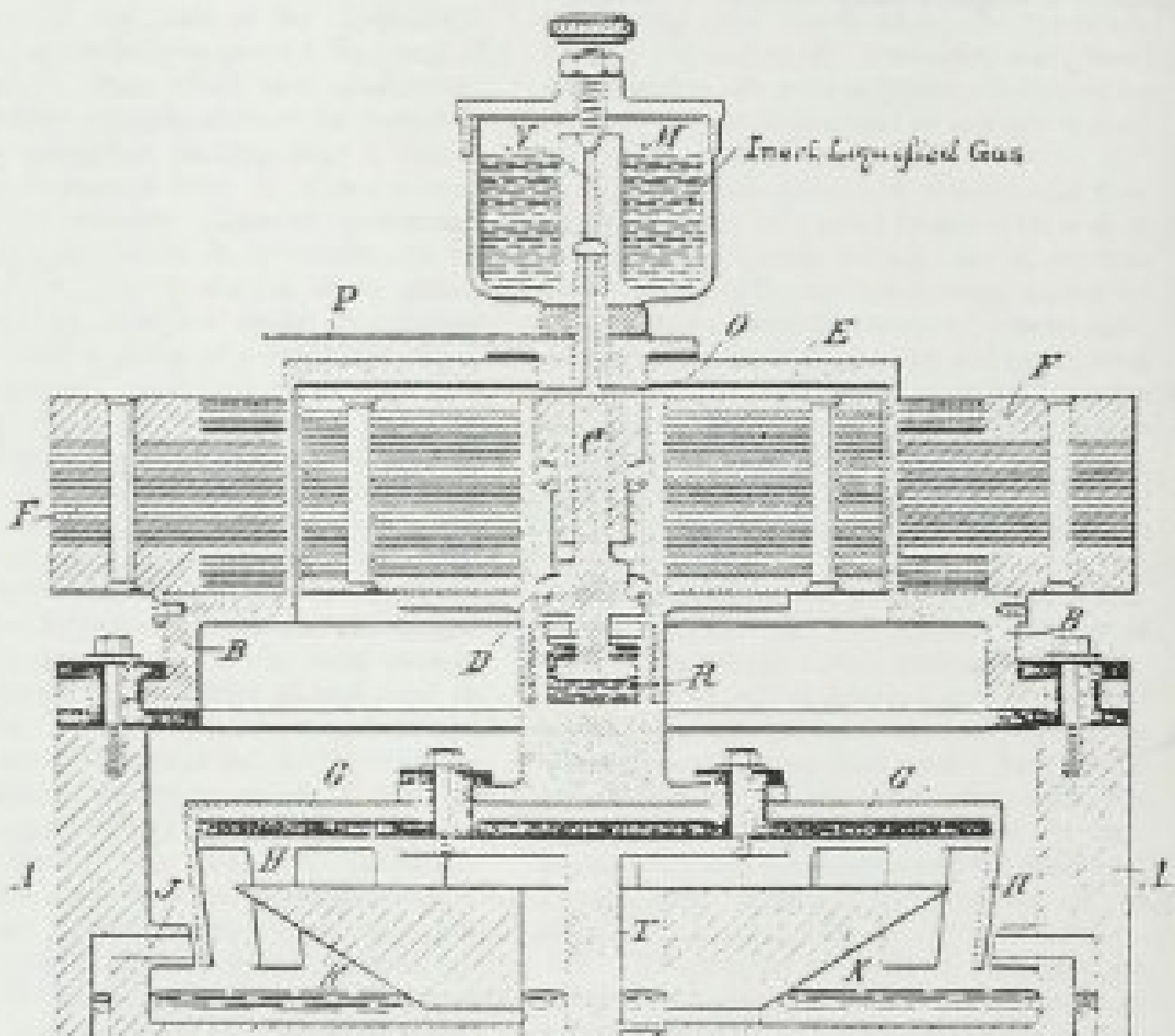
Patented Oct. 4, 1898.

N. TESLA.

ELECTRICAL CIRCUIT CONTROLLER.

(Application filed Dec. 10, 1897.)

No Model.



THE COMPLETE PATENTS OF NIKOLA TESLA

NIKOLA TESLA, OF NEW YORK, N. Y.

ELECTRICAL-CIRCUIT CONTROLLER.

SPECIFICATION forming part of Letters Patent No. 611,719, dated October 4, 1898.

Application filed December 10, 1897. Serial No. 661,403. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electrical-Circuit Controllers, of which the following is a specification, reference being had to the drawings accompanying and forming part of the same.

In order to secure a more efficient working of circuit-controllers, particularly in their use in connection with my system of electrical-energy conversion by means of condenser discharges, I have devised certain novel forms of such appliances, comprising as essential elements a body of conducting fluid constituting one of the terminals, a conductor or series of conductors forming the other terminal, and means for bringing the two into rapidly-intermittent contact with each other. These devices possess many desirable qualities, particularly that of being eminently adapted for making and breaking at a very rapid rate an electric circuit and thus reducing to a minimum the time of passage of the current through an arc or path of high resistance and diminishing thereby the losses incident to the closure and interruption of the circuit. Continued experimentation with these appliances has led me to make further important improvements by causing the make-and-break to be effected in an inert medium of very high insulating power.

It is a fact, which was fully demonstrated by Poggendorff and utilized by him to improve the operation of induction-coils, that when the contact-points of a circuit-breaker

with my novel circuit-controllers; but inas-
much as only a very moderate improvement
is secured in this manner and as the high vacuum required is quickly destroyed and cannot
be maintained, unless by a continuous process
of rarefaction and other inconvenient measures, I have found it desirable to employ
more effective and practical means to increase
the efficiency of the devices in question. The
measures I have adopted for this purpose have
resulted from my recognition of certain ideal
qualifications of the medium wherein to effect
a make-and-break. These may be summed up
as follows: First, the medium by which the
contact-points are surrounded should have as
high an insulating quality as possible, so that
the terminals may be approached to an extremely short distance before the current leaps
across the intervening space; second, the closing up or repair of the injured dielectric, or, in
other words, the restoration of the insulating
power, should be instantaneous in order to
reduce to a minimum the time during which
the waste principally occurs; third, the medium should be chemically inert, so as to diminish
as much as possible the deterioration
of the electrodes and to prevent chemical processes which might result in the development
of heat or, in general, in loss of energy; fourth, the giving way of the medium under the application
of electrical pressure should not be of
a yielding nature, but should be very sudden
and in the nature of a crack, similar to that
of a solid, such as a piece of glass when
squeezed in a vise, and, fifth, most important,
the medium ought to be such that the arc

THE COMPLETE PATENTS OF NIKOLA TESLA

NIKOLA TESLA, OF NEW YORK, N. Y.

ELECTRICAL-CIRCUIT CONTROLLER.

SPECIFICATION forming part of Letters Patent No. 609,245, dated August 16, 1898.

Application filed December 2, 1897. Serial No. 660,518. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electrical-Circuit Controllers, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

In every form of electrical apparatus involving a means for making and breaking, more or less abruptly, a circuit a waste of energy occurs during the periods of make or break, or both, due to the passage of the current through an arc formed between the receding or approaching terminals or contacts, or, more generally, through a path of high resistance. The tendency of the current to persist after the actual disjunction or to precede the conjunction of the terminals exists in varying degrees in different forms of apparatus, according to the special conditions present. For example, in the case of an ordinary induction-coil the tendency to the formation of an arc at the break is, as a rule, the greater, while in certain forms of apparatus I have invented in which the discharge of a condenser is utilized this tendency is greatest at the instant immediately preceding the conjunction of the contacts of the circuit-controller which effects the discharge of the condenser.

The loss of energy occasioned by the causes mentioned may be very considerable and is generally such as to greatly restrict the use of the circuit-controller and render impossible a practical and economical conversion of considerable amounts of electrical energy by its

appears that the loss of energy in any device for making and breaking a circuit, other conditions being the same, is inversely proportional rather to the square than to the first power of the speed or relative velocity of the terminals in approaching and receding from one another in an instance in which the current-curve is not so steep as to materially depart from one which may be represented by a sine function of the time; but such a case seldom obtains in practice. On the contrary, the current-curve resulting from a make and break is generally very steep and particularly so when, as in my system, the circuit-controller effects the charging and discharging of a condenser, and consequently the loss of energy is still more rapidly reduced by increased velocity of approach and separation. The demonstration of these facts and the recognition of the impossibility of attaining the desired results by using ordinary forms of circuit-controllers led me to invent new and essentially different means for making and breaking a circuit in which I have utilized a conducting fluid, such as mercury, as the material for one or both of the terminals and devised novel means for effecting a rapidly-intermittent contact between the fluid and a conductor or series of conductors forming the other terminal.

With a view, however, to securing a more practical and efficient circuit-controller in which not only the relative speed of the terminals but also the frequency of the makes and breaks should be very high I devised the form of instrument described in an application filed by me June 3, 1897. Serial No. 639,227, in

THE COMPLETE PATENTS OF NIKOLA TESLA

course the smaller the greater the diameter of the rotated conductor or terminal.

With the object of securing a greater relative speed of the terminals and a consequently more efficient form of circuit-controller of this type I devised the modified form of apparatus which constitutes the subject of my present application.

In this apparatus one of the members or terminals is a conducting fluid which is caused to issue from an orifice against a series of spaced conductors in rapid succession. For this purpose the series of conductors, or it may be a single conductor, is moved transversely through the stream or jet of fluid, or the jet is moved so as to impinge upon the conductors, or both jet and conductors are moved. This is preferably accomplished by mounting the conductors and the tube or duct from which the fluid issues concentrically and revolving one or both.

The chief feature of novelty which distinguishes the apparatus and in which my improvement resides is the plan adopted for maintaining the stream or jet of conducting fluid. This consists in utilizing the same power that actuates or drives the circuit-controller in effecting the necessary relative movement of its terminals to maintain the proper circulation of the conducting fluid by combining the two mechanisms (the controller and the means for maintaining a circulation of the conducting fluid) in one. This feature is of great practical advantage and may be effected in many ways. A typical arrangement for this purpose is to provide a tube or duct having an orifice at one end directed toward the spaced conductors and its other end in a position to take up a portion of the rapidly-rotating body of conducting fluid, divert it through the duct, and discharge it against the conductors. With this object when a closed receptacle is used a holder for the tube is employed, mounted within the receptacle and concentrically therewith, and this holder, when the receptacle is revolved, is held or influenced by any suitable means, as by magnetic attraction exerted from the outside or otherwise, in such manner as

terminals.

In the drawings hereto annexed, Figure 1 is a diagram illustrating the system for which the improvement was more especially designed. Fig. 2 is a top plan view of the circuit-controller. Fig. 3 is a view showing the induction-coil of Fig. 1 with its condenser-case in side elevation and the circuit-controller in vertical central section.

The general scheme of the system for use with which my improved circuit-controller is more especially designed will be understood by a brief reference to Fig. 1. In said figure, $A A$ represent the terminals of a source of current. A' is a self-induction or choking coil included in one branch of the circuit and permanently connected to one side of a condenser A'' . The opposite terminal of this condenser is connected to the other terminal of the source through the primary B of a transformer, the secondary B' of which supplies the working circuit containing any suitable translating devices, as B'' .

The circuit-controller C , which is represented conventionally, operates to make and break a bridge from one terminal of the source to a point between the choking-coil A' and the condenser A'' , from which it will result that when the circuit is completed through the controller the choking-coil A' is short-circuited and stores energy which is discharged into the condenser when the controller-circuit is broken, to be in turn discharged from the condenser through the primary B when those two are short-circuited by the subsequent completion of the controller-circuit.

I refer now to Figs. 2 and 3 for an illustration of the more important and typical features of my improved circuit-controller. The parts marked a compose a closed receptacle of cylindrical form having a dome or extension of smaller diameter. The receptacle is secured to the end of a spindle c , which is mounted vertically in bearings of any character suitable for the purpose. As it is intended to impart a rapid rotation to the receptacle a , I have shown a convenient device for this purpose comprising a field-magnet d secured to the

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11. The combination with a centrifugal drum containing a conducting and a non-conducting fluid, means for rotating the drum, a terminal capable of rotation and having peripheral projections, mounted within the drum on a stationary support, and a spring or its equivalent acting on the said terminal and tending to force its projections toward the inner periphery of said drum, as set forth.

12. The combination with a receptacle containing a conducting fluid, a lighter fluid of

and break the circuit by movements between the conducting and non-conducting fluid through the intermediate fluid of low conductivity, as set forth.

NIKOLA TESLA.

Witnesses:

M. LAWSON DYER,
PARKER W. PAGE.

THE COMPLETE PATENTS OF NIKOLA TESLA

No. 809,245.

Patented Aug. 16, 1898.

N. TESLA. ELECTRICAL CIRCUIT CONTROLLER.

(Apparatus filed Dec. 3, 1897.)

(See Model.)

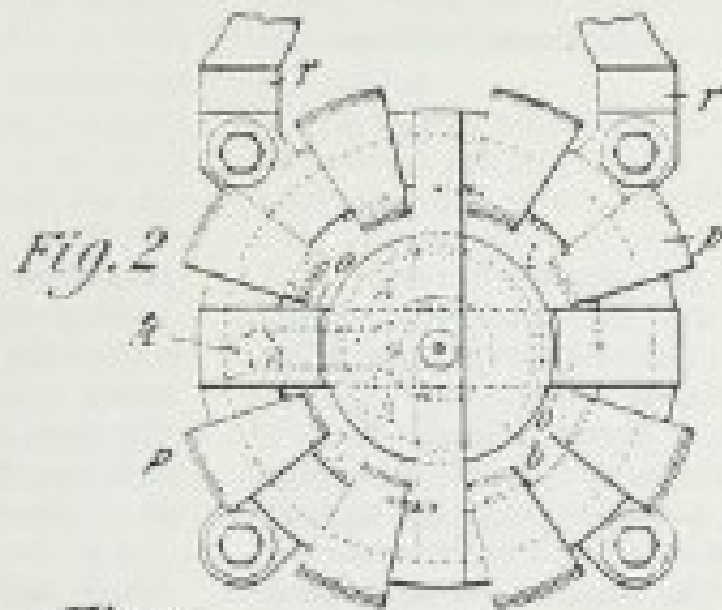
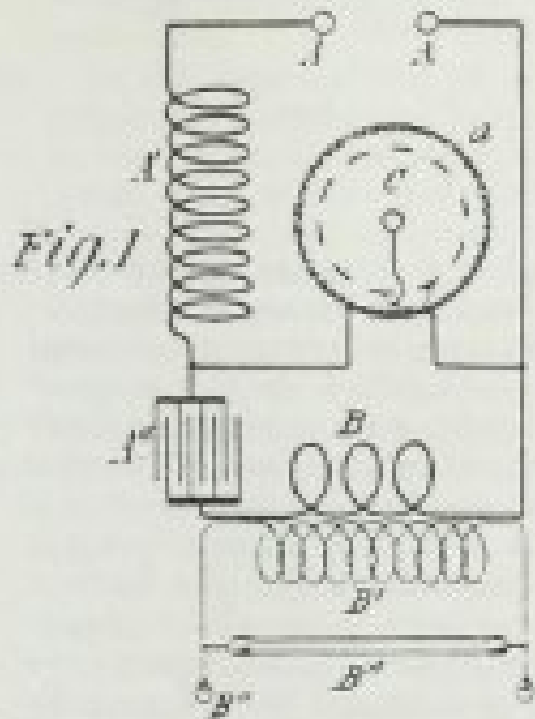
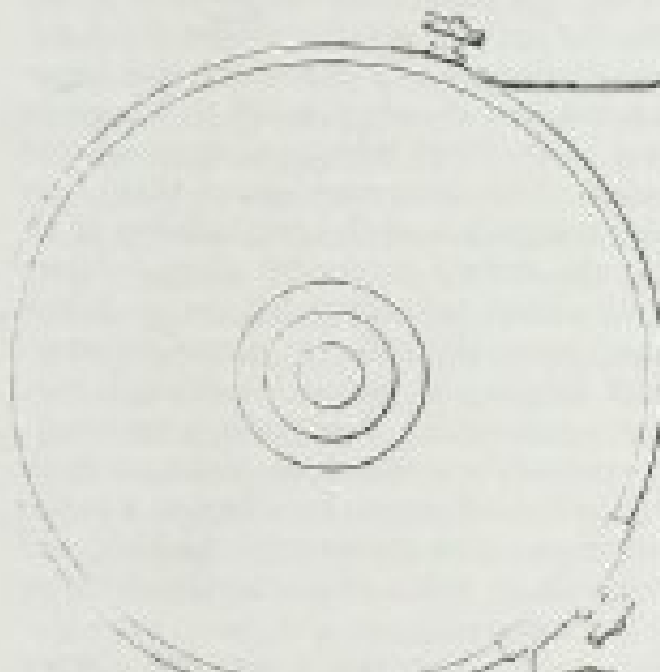
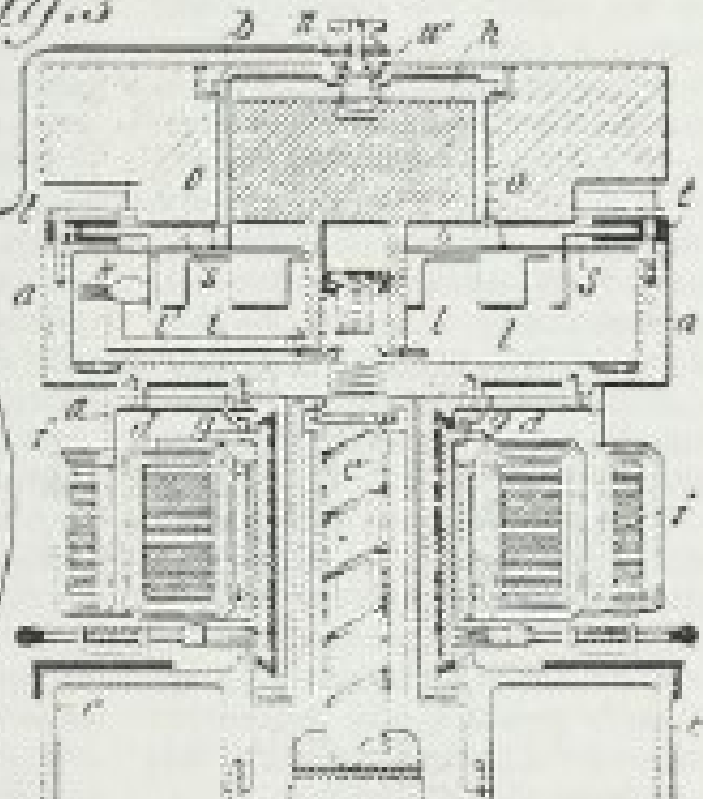


Fig. 3



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No. 609,231.

Patented Aug. 16, 1898.

N. TESLA.

ELECTRIC CIRCUIT CONTROLLER.

(Application filed June 3, 1897. Renewed June 15, 1898.)

(No Model.)

2 Sheets—Sheet 2.

Fig. 4

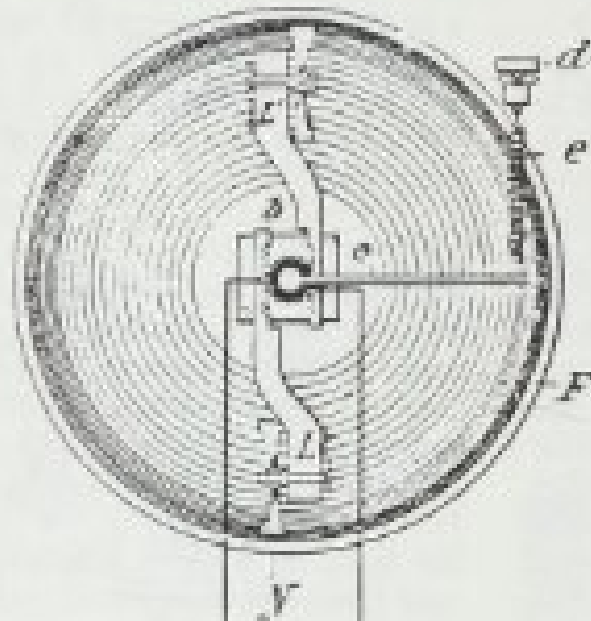
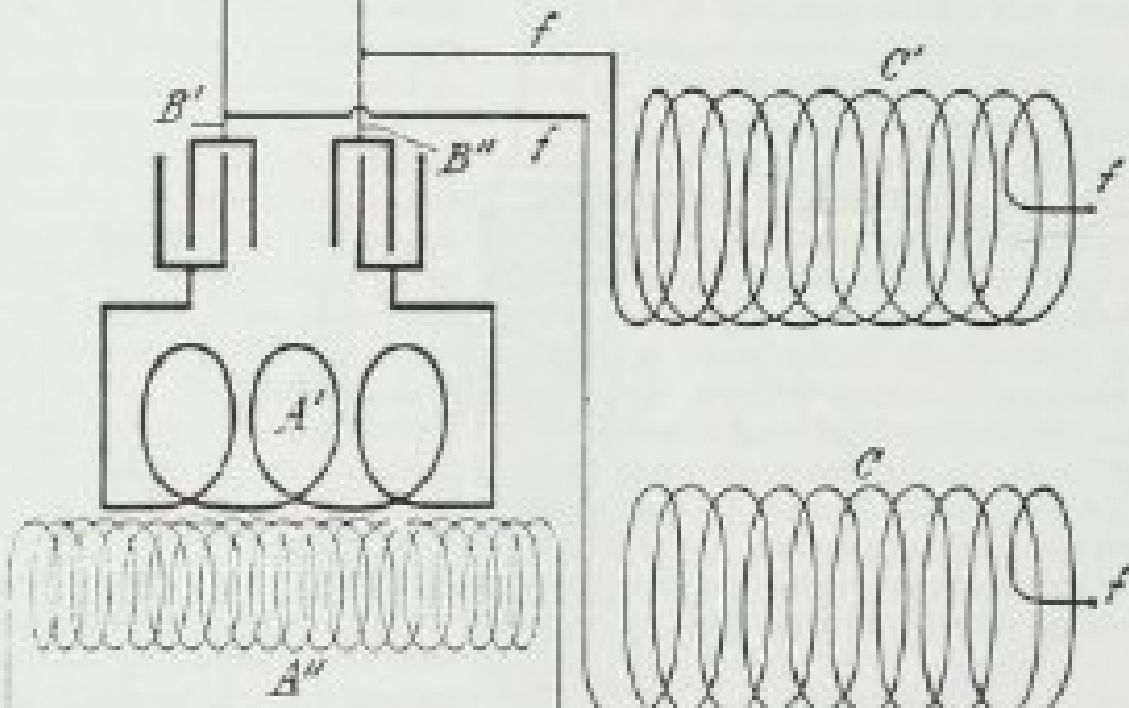
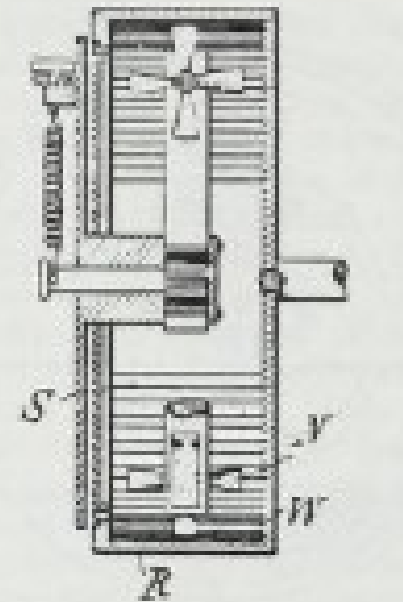


Fig. 5



THE COMPLETE PATENTS OF NIKOLA TESLA

NIKOLA TESLA, OF NEW YORK, N. Y.

ELECTRIC-CIRCUIT CONTROLLER.

SPECIFICATION forming part of Letters Patent No. 609,251, dated August 16, 1898.

Application filed June 3, 1897. Renewed June 15, 1898. Serial No. 683,525. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electric-Circuit Controllers, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

In previous patents granted to me I have shown and described methods and apparatus for the conversion and utilization of electrical currents of very high frequency based upon the principle of charging a condenser or a circuit possessing capacity and discharging the same generally through the primary of a transformer, the secondary of which constituted the source of working current and under such conditions as to yield a vibrating or rapidly-intermittent current.

In some of the forms of apparatus which I have heretofore devised for carrying out this invention I have employed a mechanism for making and breaking an electric circuit or branch thereof for the purpose of charging and discharging the condenser, and my present application is based upon a novel and improved form of device for this purpose, which may be generally styled a "circuit-controller."

In order that the full advantages of my system may be realized and the best practical results secured, the said circuit-controller should be capable of fulfilling certain requirements, the most important among which is the capa-

which may in general terms be described as follows:

The device in its typical embodiment comprises as essential elements two terminals—one with peripheral contacts alternating with insulating-spaces, such as is exemplified in a stelliform disk and which is capable of rotation, and the other a rotatable receptacle containing a fluid in which more or less of the first-named terminal is immersed.

In the preferred construction of the apparatus the receptacle contains both a conducting and a non-conducting fluid, the former being the heavier, and I maintain the terminals in such relations that the electrical connection between them is made and broken by the successive immersion of the contact-points into and their withdrawal from the conducting through the non-conducting fluid. These relations are best maintained by such construction of the receptacle that the distribution of the two fluids necessary for the proper operation of the device may be preserved by centrifugal action and the rotation of the other terminal effected by the movement of the fluid or fluids relatively thereto.

To secure the conditions necessary for the accomplishment of the objects of the invention, various mechanical expedients may be resorted to; but the best and most practicable device for the purpose of which I am aware is a hollow wheel or drum mounted so as to be rotated at any desired speed and containing a conducting fluid, such as mercury or an elec-

THE COMPLETE PATENTS OF NIKOLA TESLA

two or more of each. The brush D of one set is connected with one main through the coils F, and each one of the brushes of the same set is connected to one of the terminals of the condensers M N, respectively. Similarly the brush E of the other set of brushes is connected to the opposite main and each of the brushes of said set to the opposite condenser terminals through the primary or strands of a primary G. In the diagram, Fig. 2, I have shown but two brushes in each set and two condensers, but more than this number may be used, the same plan of connections shown and described being followed out.

In the position of the parts shown in Fig. 2, in which two positive and two negative brushes are shown, the brushes are bearing on plates *m m* and *n n*. Consequently the circuit through the coils F F is through the condensers in multiple, and, assuming that energy has been stored in said coils the condensers will thus be charged. If now by the movement of the controller plates or brushes the latter are shifted across the idle or spacing plates *p* onto the long or cross-connected plates *a* two results follow: The mains are short-circuited through the coils F F, which therefore store energy, while the condensers are connected in series through the primary coil or coils G. These actions are repeated by the further movement of the controller, the condensers being charged in parallel when the brushes are on plates *m n* and discharged in series when the brushes pass onto plates *a*. The motor may be run by an independent source or by current derived from the mains, and the apparatus may be employed to supply current for any suitable devices S T, connected with the secondary coil H.

As stated above, the specific construction of the circuit-controller may be very greatly varied without departure from the invention. In the drawings the plates are assumed to be associated in the form of a cylinder which revolves with respect to brushes bearing on its periphery; but it will be understood that this is merely a typical illustration of any form of terminals or contacts and conductors, whether

sion of the condenser or the employment of a plurality of condensers are mainly that a high frequency is obtainable in apparatus of any size; that the current of discharge through the sliding contacts is greatly reduced and injury to such contacts thereby avoided and a great saving in wire in the secondary effected.

What I claim is—

1. In an apparatus of the kind described, the combination with a set of contacts, one of which is adapted for connection with one of the mains from a source of current, and each of which is connected to one of the terminals of a series of condensers, and a second set of contacts similarly connected to the opposite main and condenser terminals, respectively, of electrically-connected plates or segments upon which the contacts of the first set bear, similarly connected plates upon which the contacts of the second set bear, and isolated plates common to the two sets of contacts, the said plates being arranged in the manner described, whereby the condensers will be alternately charged in multiple and discharged in series, as set forth.

2. In an apparatus of the kind described, the combination with a set of positive brushes, one of which is adapted for connection with one of the mains from a source of current, and each of which is connected to one of the terminals of a series of condensers, and negative brushes similarly connected to the opposite main and condenser terminals, respectively, of a cylinder composed of electrically-connected segments upon which the positive brushes only bear, similarly-connected segments upon which the negative brushes only bear, and isolated plates upon which both sets of brushes simultaneously bear, the said plates being arranged in the manner described, whereby the condensers will be alternately charged in multiple and discharged in series, as set forth.

NIKOLA TESLA.

Witnesses

M. LAWSON DYER,

DRURY W. COOPER.

THE COMPLETE PATENTS OF NIKOLA TESLA

No. 609,251.

Patented Aug. 16, 1898.

N. TESLA.

ELECTRIC CIRCUIT CONTROLLER.

(Application filed June 3, 1897. Renewed June 15, 1898.)

(No Model.)

2 Sheets—Sheet 1.

Fig. 3

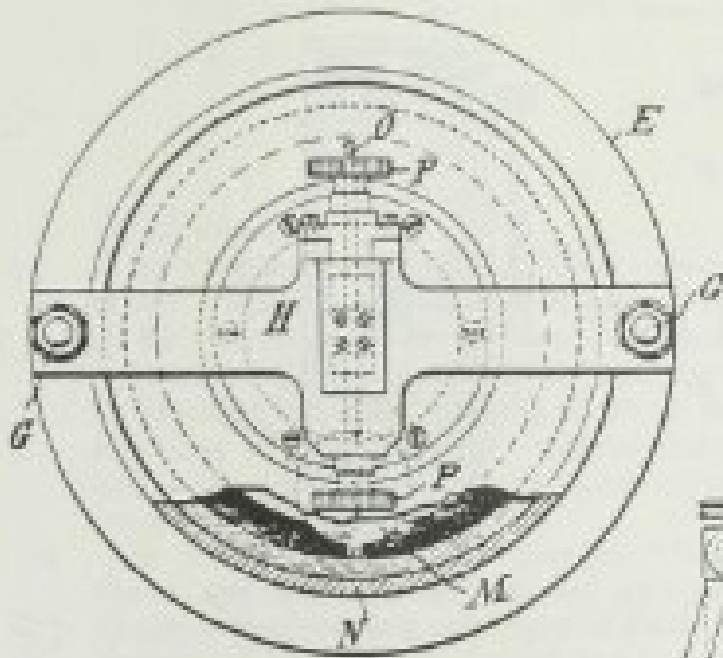


Fig. 2

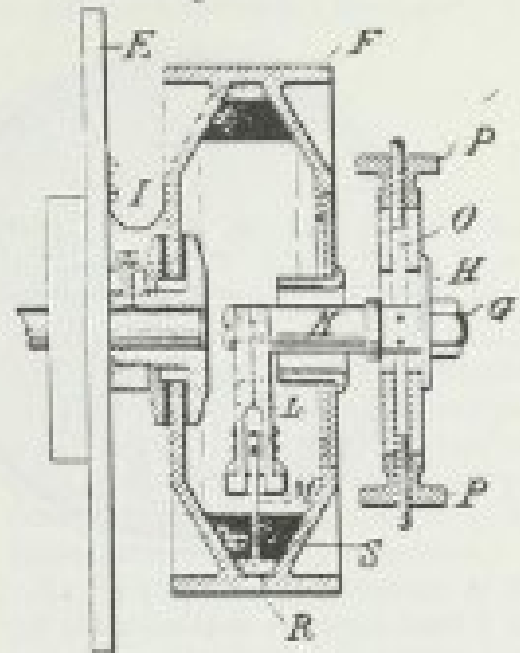
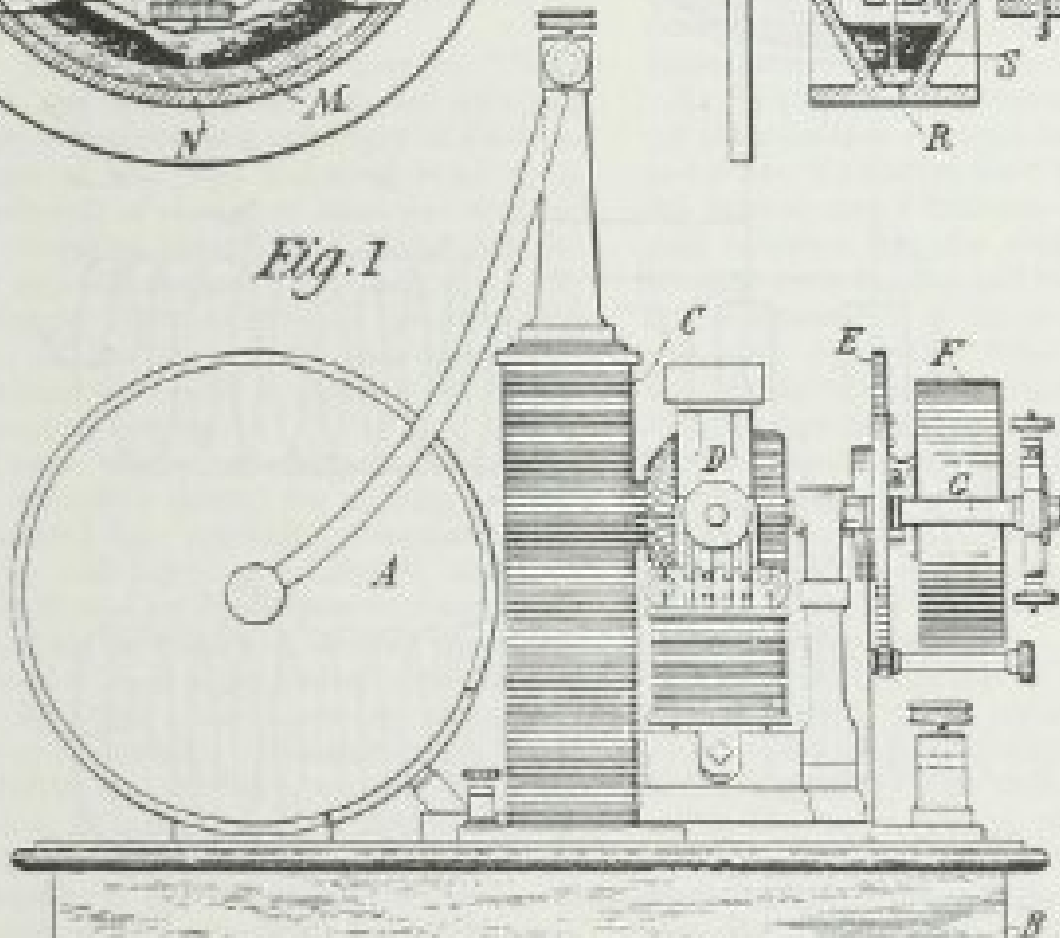


Fig. 1



THE COMPLETE PATENTS OF NIKOLA TESLA

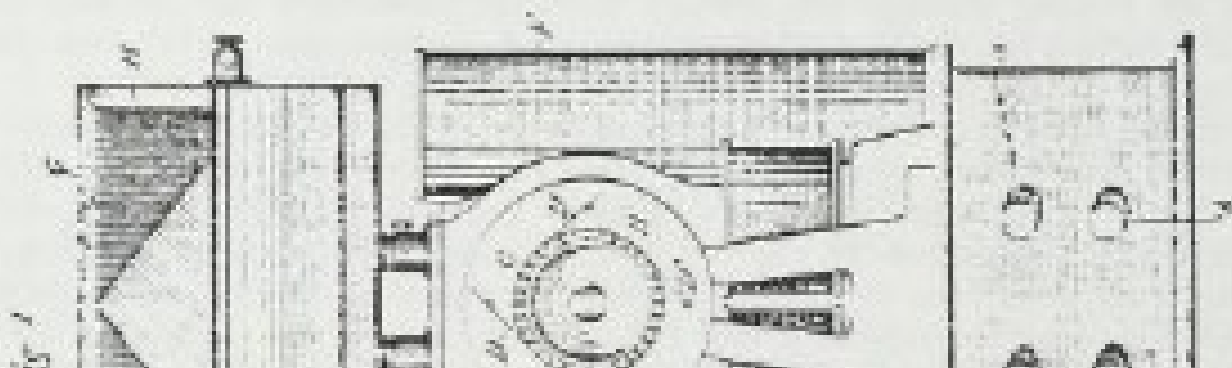
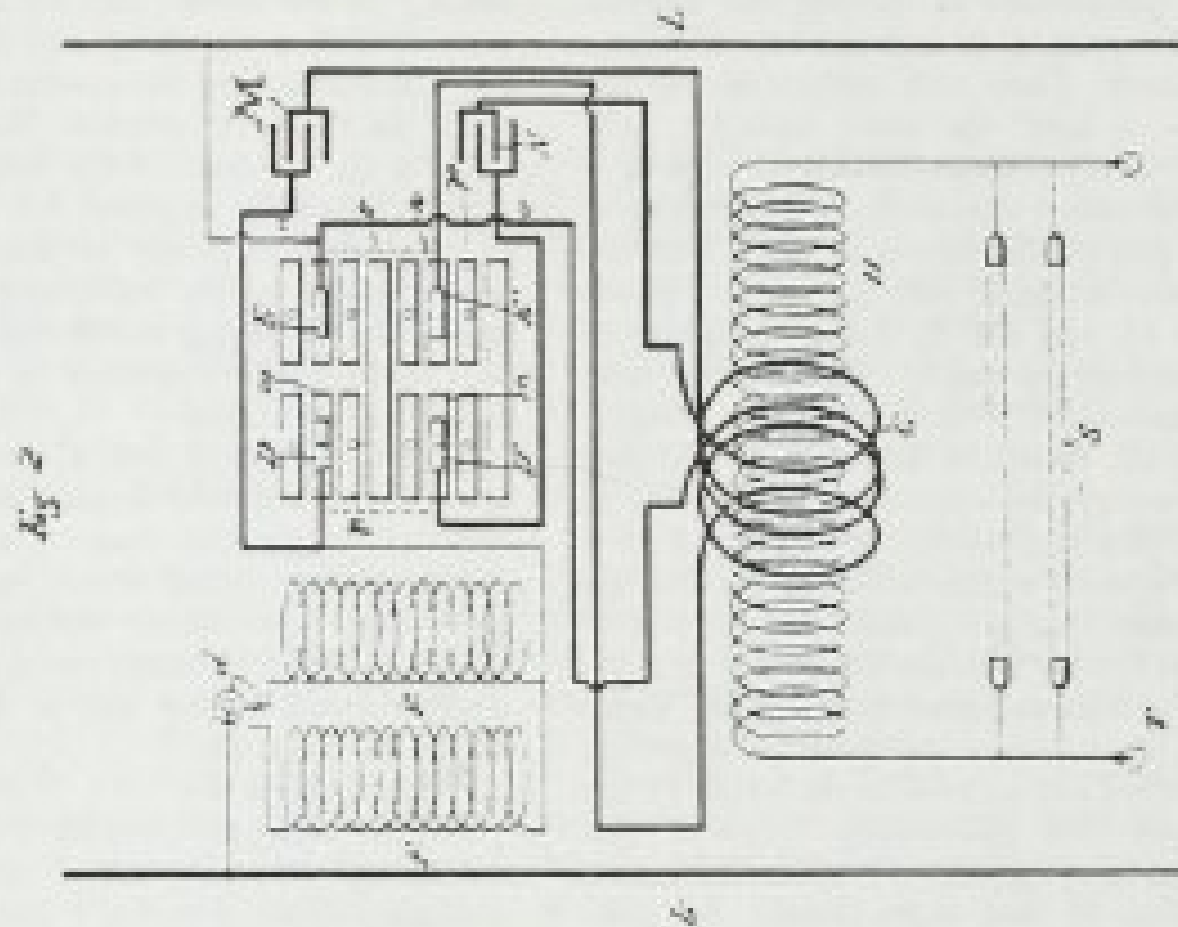
(No Model.)

N. TESLA.

APPARATUS FOR PRODUCING CURRENTS OF HIGH FREQUENCY.

No. 583,953.

Patented June 8, 1897.



THE COMPLETE PATENTS OF NIKOLA TESLA

NIKOLA TESLA, OF NEW YORK, N. Y.

APPARATUS FOR PRODUCING CURRENTS OF HIGH FREQUENCY.

SPECIFICATION forming part of Letters Patent No. 583,953, dated June 8, 1897.

Application filed October 19, 1896. Serial No. 609,292. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Apparatus for Producing Currents of High Frequency, of which the following is specification, reference being had to the drawings accompanying and forming a part of the same.

The invention upon which my present application is based is an improvement in apparatus for the conversion of electrical currents of ordinary character—such, for instance, as are obtainable from the mains of municipal electric light and power systems and either continuous or alternating—into currents of very high frequency and potential.

The improvement is applicable generally to apparatus of the kind heretofore invented by me and more particularly described in United States Letters Patent granted to me on September 22, 1896, No. 568,176; but in the description of the invention which follows the illustration is confined to a form of apparatus designed for converting a continuous or direct current into one of high frequency. In the several forms of apparatus for this purpose which I have devised and heretofore described I have employed a circuit of high self-induction connected with the mains from a suitable source of current and containing some form of circuit-controller for periodically interrupting it. Around the break or point of interruption I have arranged a condenser, into which the circuit discharges when interrupted, and this condenser is in turn made to discharge

the transformer. To secure this result without unduly complicating the apparatus is a matter of very considerable difficulty, but I have accomplished it by means of the apparatus which I shall now proceed to describe by reference to the drawings.

Figure 1 is a side elevation of the apparatus which I employ, and Fig. 2 is a diagram of the circuit connections.

Referring to Fig. 1, A is a box or case containing the condensers, of which the terminals are *a a b b*, respectively. On this case is mounted a small electromagnetic motor B, by the shaft of which is operated the circuit-controller C. Upon the said controller bear brushes, as shown at D D' D" D".

F F are self-induction coils placed beside the motor. Above these is the transformer, composed, essentially, of a primary G and a secondary H. These devices are intended to be inclosed in a suitable box or case, and may be very greatly modified in construction and relative arrangement. The circuit-controller, however, should conform in general principle of construction to that hereinafter described in so far as may be necessary to secure the operation pointed out.

Referring now to Fig. 2, L L designate the mains from a suitable source of supply, between which a circuit is formed, including the self-induction coils F F and the circuit-controller C. A switch *d* may be employed to bring either or both of the coils F F into this circuit, as may be desired.

The circuit-controller is built up of insulated plates or segments upon which the

THE COMPLETE PATENTS OF NIKOLA TESLA

APPARATUS FOR PRODUCING ELECTRIC CURRENTS OF HIGH FREQUENCY.

SPECIFICATION forming part of Letters Patent No. 577,670, dated February 23, 1897.
Application filed September 3, 1896. Serial No. 604,723. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Apparatus for Producing Electric Currents of High Frequency, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

The apparatus for converting electric currents of ordinary character into those of high frequency, which I have heretofore shown and described in applications for Letters Patent, has usually comprised a condenser and a circuit-controller operated by a suitable motive device and acting to alternately charge the condenser from a suitable source of supply and discharge it through a circuit of such character as to render the discharge one of very high frequency. For many purposes it has been found advantageous to construct the circuit-controller with insulating and conducting segments of equal length, so that the condenser is connected with its discharge-circuit during one-half of the time only. It follows from this that the working circuit, or that in which the high-frequency currents are developed in form for practical application, receives such currents during only one-half the time.

For certain purposes it is desirable for economical operation that there should be no cessation of the flow of such currents, and my present improvements have been devised with the object of increasing the output of a given apparatus by providing means by which, without material additions to or complication of such apparatus, high-frequency currents may be produced thereby continuously or without

and circuit connections of the invention. Fig. 2 is a sectional view of a part of the commutator employed; and Fig. 3 is a diagram similar to that of Fig. 1, illustrative of a modified embodiment of the invention.

Let A B designate the two conductors of any circuit from which the energy is derived that is to be converted into a current of high frequency.

C is a circuit controller or commutator, a portion only for convenience being shown in the figures. It is designed to be rotated by any suitable motive device, of which, however, the shaft D only is shown, and its plan of construction is as follows:

The letters *c c'* designate two metal heads or castings with projecting portions *d d'*, which, when the two heads are brought together and secured to a hub or shaft, intermesh, as shown in the drawings.

The spaces between two adjacent projections or bars *d d'* are equal in arc to the width of one of said bars and are filled in with blocks *e*, preferably of metal, insulated from the other conducting portions of the device. By the interposition of mica or other suitable insulating material the two heads or castings *c c'* are insulated from each other. Upon the periphery of this commutator bear three brushes G G' H, the two former resting upon the continuous metallic portions of the two heads, respectively, the latter being in position to bear upon the projections *d d'* and blocks *e* alternately.

In order that the brushes may be capable of carrying any current which the operation of the apparatus may demand, they are made of large cross-section, the brush H being approximately equal in width to one of the projections or segments *d d'*, or to the space between

THE COMPLETE PATENTS OF NIKOLA TESLA

coils O O', these latter being used in order that the inductive discharge of the accumulated energy therein may be taken advantage
105 of in charging the condensers.

The operation of the apparatus thus described as follows: By the rotation of the commutator C the brush H is caused to pass over the projections *d*, closing the circuits
110 through the primary K and the two condensers alternately. These two circuits are so adjusted as to have the same capacity, self-induction, and resistance. When said brush is in electrical connection with any projection *d'*
115 from the part *c'*, the circuit is closed and between mains A and B through coil O', brush G', brush H, and coil K. Energy is therefore accumulated in the coil O'. At the same time the condenser N' is short-circuited through
120 the brush G', brush H, and coil K, and discharges through this circuit the energy stored in it, the discharge being in the form of a series of impulses which induce in the secondary L corresponding impulses of high potential.
125 When brush H breaks the circuit through coil O', the high-potential discharge or "kick" from the latter rushes into and recharges the condenser N', but as soon as the brush H has passed over the intervening block *e* and
130 reached the next segment *d* it closes the circuit through coil O and short-circuits the condenser N, so that high-frequency currents from either one or the other of the two condensers are flowing through the primary K
135 practically without interruption. Thus without increasing the size or power of the motive device or complicating in any material degree the commutator these devices are made to perform double duty and the output of the apparatus
140 as a whole greatly increased. In Fig. 3 I have illustrated a modified form of commutator for this apparatus, which comprises a disk E, of metal, but insulated from its shaft. The periphery of this disk is divided into conducting
145 and insulated segments by the insertion therein of insulated metal blocks *f*. The circumferential width of these blocks is three times that of the conducting-segments *f'*. A brush F bears upon a continuous metallic portion
150 of the disk or upon a continuous ring in electrical connection with the commutator *d'* and

through the two condensers, respectively. 155 These brushes are capable of angular adjustment, so that they may be set to bear upon the disk at any two desired points.

From the explanation of the operation already given it is evident that when the two
160 brushes F' F'' are set so that one leaves a segment *f'* at the instant that the other comes in contact with a segment *f'* the effect in charging and discharging the condensers is the same as in the previous instance. The capability of
165 varying the relations of the brushes, however, which this form possesses has the advantage of permitting not only an alternate charging and discharge of the condensers, but their simultaneous charging and discharge in multiple
170 arc, whereby the frequency of the current of discharge is reduced.

It is also evident that all phase differences in the charging and discharging of the condensers may in like manner be secured and
175 the frequency varied within wide limits. Of course the same motor and circuit-controller might be made to charge more, than two condensers in succession and to discharge them
180 in the same order.

What I claim is—

1. The combination with a source of electric energy, of a plurality of condensers and a discharge-circuit therefor, a motive device and a circuit-controller operated thereby and
185 adapted to direct the energy of the source into the condensers and connect them with the discharge-circuit successively and in alternation, as set forth.

2. The combination with a source of electric energy, of a motive device, two condensers, a circuit-controller adapted to direct the energy of the source alternately into the said
190 condensers, and a discharge-circuit through which, by the operation of said circuit-controller one condenser discharges while the other is being charged, as set forth.

NIKOLA TESLA.

Witnesses:

M. LAWSON DYER,
DRURY W. COOPER.

THE COMPLETE PATENTS OF NIKOLA TESLA

Key Words

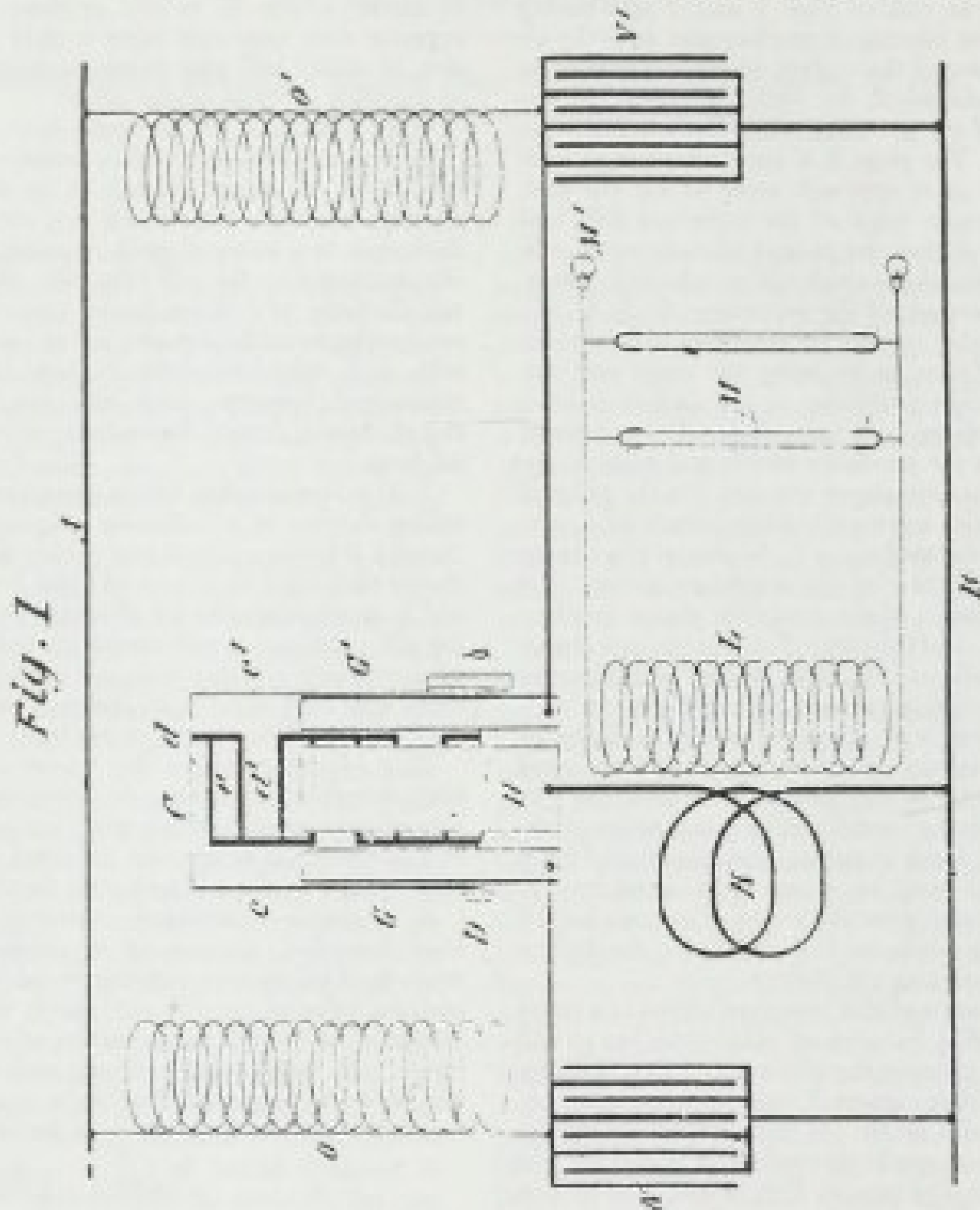
2 Sheets—Sheet 1

N. TESLA

APPARATUS FOR PRODUCING ELECTRIC CURRENTS OF HIGH FREQUENCY.

No. 577,670.

Patented Feb. 23, 1897.



THE COMPLETE PATENTS OF NIKOLA TESLA

(No Model.)

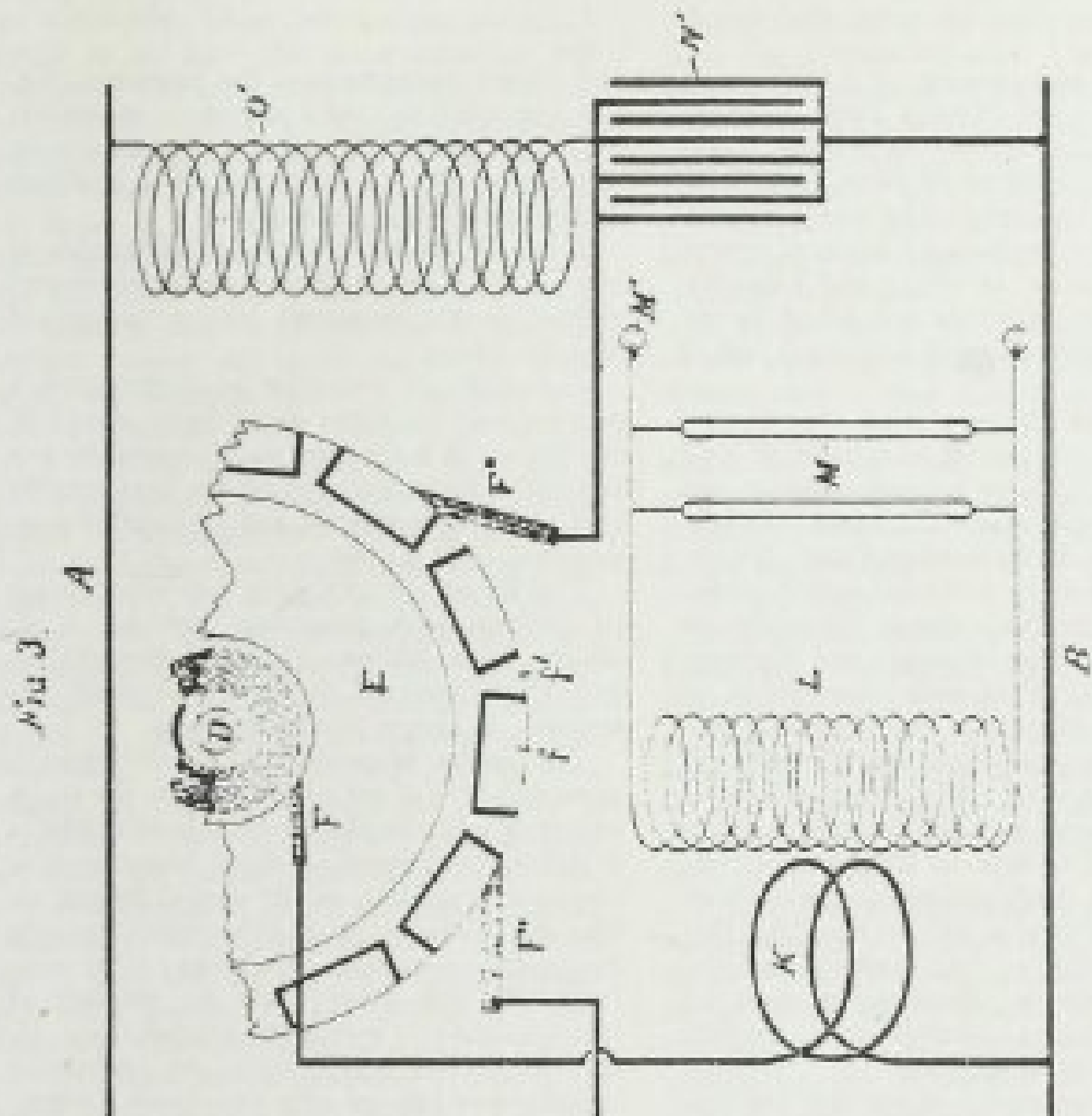
2 Sheets—Sheet 2

N. TESLA.

APPARATUS FOR PRODUCING ELECTRIC CURRENTS OF HIGH FREQUENCY.

No. 577,670.

Patented Feb. 23, 1897.



THE COMPLETE PATENTS OF NIKOLA TESLA

NIKOLA TESLA, OF NEW YORK, N. Y.

APPARATUS FOR PRODUCING ELECTRICAL CURRENTS OF HIGH FREQUENCY.

SPECIFICATION forming part of Letters Patent No. 568,180, dated September 22, 1896.

Application filed July 9, 1896. Serial No. 598,552. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have
5 invented certain new and useful Improvements in Apparatus for Producing Electrical Currents of High Frequency, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

This invention is an improvement in apparatus for producing electrical currents of high frequency in accordance with the general plan heretofore invented and practiced by me and
15 based upon the principle of charging a condenser or circuit possessing capacity and discharging the same through a circuit of low self-induction, so that rapid electrical oscillations are obtained. To secure this result, I employ some means for intermittently charging the condenser and for discharging it through the circuit of low self-induction; and among the
20 means which I have heretofore employed for this purpose was a mechanical contact device which controlled both the charging and the discharge circuit in such manner that the condenser was alternately charged by the former and discharged into the latter.

My present improvement consists in an apparatus for effecting the same result by the use
25 of a circuit-controller of special character in which the continuity of the paths for the current is established at intervals by the passage of sparks across a dielectric.

tion and partly in section, of a generator arranged to give an alternating current with the
30 circuit-controller mounted on its shaft. Fig. 2 is a section of the controller of Fig. 1 on line *x x* of said figure. Fig. 3 is a diagram illustrating the system or apparatus as a whole. Figs. 4 and 5 are sectional views of a modified form of circuit-controller.

A designates in Fig. 1 a generator having a commutator A' and brushes A" bearing thereon, and also collecting-rings B B, from
35 which an alternating current is taken by brushes B' in the well-understood manner.

The circuit-controller is mounted in part on an extension of the shaft C of the generator, and in part on the frame of the same, or on
40 a stationary sleeve surrounding the shaft. Its construction in detail is as follows: D is a metal plate with a central hub D', which is keyed or clamped to the shaft C. The plate is formed with segmental extensions corresponding in number to the waves of current which
45 the generator delivers. These segments are preferably cut away, leaving only rims or frames, to one of the radial sides of which are secured bent metal plates E, which serve as
50 vanes to maintain a circulation of air when the device is in operation. The segmental disk and vanes are contained within a close insulated box or case F, mounted on the bearing of the generator, or in any other proper way,
55 but so as to be capable of angular adjustment around the shaft. To facilitate such adjustment, a screw-rod F', provided with a knob

THE COMPLETE PATENTS OF NIKOLA TESLA

any source of alternating current the potential of which is raised by a transformer, of which *a* is the primary and *b* the secondary. The
105 ends of the secondary circuit *S* are connected to the terminal plugs *K K* of an apparatus similar to that of Figs. 1 and 2 and having segments rotating in synchronism with the alternations of the current source, preferably, as
110 above described, by being mounted on the shaft of the generator when the conditions so permit. The plugs *K K* are then adjusted radially, so as to approach more or less the path of the outer edges of the segmental disk, and
115 so that during the passage of each segment in front of a plug a spark will pass between them, which completes the secondary circuit *S*. The box or the support for the plugs *K* is adjusted angularly, so as to bring the plugs and seg-
120 ments into proximity at the desired instants with reference to any phase of the current-wave in the secondary circuit and fixed in position in any proper manner. To the plugs *K K* are also connected the terminals of a con-
125 denser or condensers *L*, so that at the instant of the rupture of the secondary circuit *S* by the cessation of the sparks the energy accumulated in such circuit will rush into and charge the condenser. A path of low self-induction
130 and resistance, including a primary *M* of a few turns, is provided to receive the discharge of the condenser, when the circuit *S* is again completed by the passage of sparks, the discharge being manifested as a succession of ex-
135 tremely rapid impulses. The potential of these impulses may be raised by a secondary *T*, which constitutes the source of current for the working circuit or that containing the devices *R* for utilizing the current.

140 By means of this apparatus effects of a novel and useful character are obtainable, but to still further increase the efficiency of the discharge or working current I have in some instances provided a means for further breaking up the individual sparks themselves. A device for this
145 purpose is shown in Figs. 4 and 5. The box or case *F* in these figures is fixedly secured to the frame or bearing of the generator or motor

on a spindle *d*, in face of the first, is mounted in a bearing in the end of the box *F* with a 155 capability of rotary adjustment. The ends of the projections *d'* are deeply serrated or several pins or narrow projections placed side by side, as shown in Fig. 4, so that as those of the opposite disks pass each other a rapid succes- 160 sion of sparks will pass from the projections of one disk to those of the other.

What I claim as my invention is—

1. The combination with a source of current, of a condenser adapted to be charged 165 thereby, a circuit into which the condenser discharges in a series of rapid impulses, and a circuit-controller for effecting the charging and discharge of said condenser, composed of conductors movable into and out of proximity 170 with each other, whereby a spark may be maintained between them and the circuit closed thereby during determined intervals, as set forth.

2. The combination with a source of alter- 175 nating current, of a condenser adapted to be charged thereby, a circuit into which the condenser discharges in a series of rapid impulses, and a circuit-controller for effecting the charging and discharge of said condenser, composed 180 of conductors movable into and out of proximity with each other in synchronism with the alternations of the source, as set forth.

3. A circuit-controller for systems of the kind described, comprising in combination a 185 pair of angularly adjustable terminals and two or more rotating conductors mounted to pass in proximity to the said terminals, as set forth.

4. A circuit-controller for systems of the kind described, comprising in combination 190 two sets of conductors, one capable of rotation and the other of angular adjustment whereby they may be brought into and out of proximity to each other, at determinate points, and one or both being subdivided so as to present 195 a group of conducting-points, as set forth.

NIKOLA TESLA.

Witnesses:

THE COMPLETE PATENTS OF NIKOLA TESLA

(No Model.)

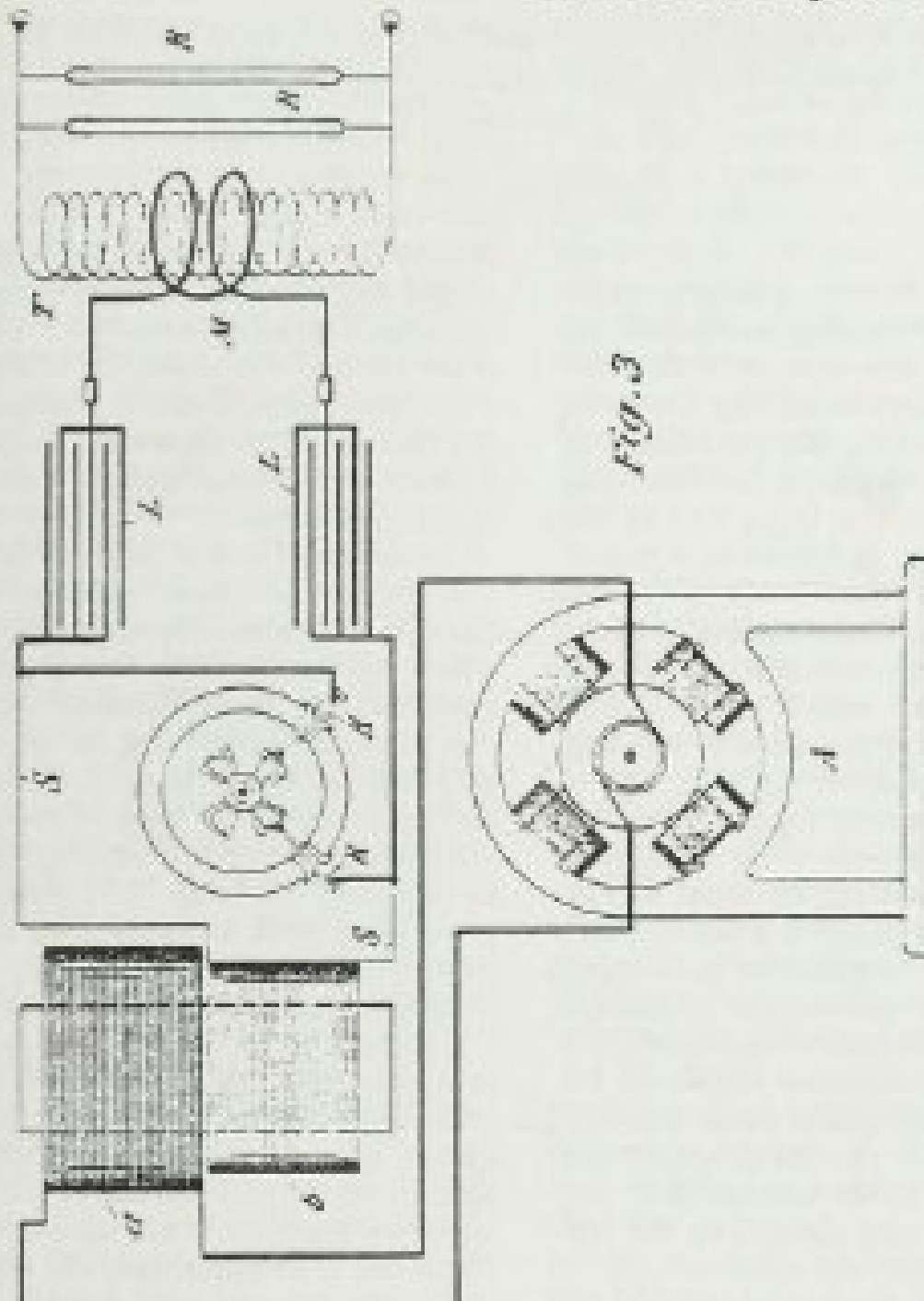
2 Sheets—Sheet 2

N. TESLA.

APPARATUS FOR PRODUCING ELECTRICAL CURRENTS OF
HIGH FREQUENCY.

No. 568,180.

Patented Sept. 22, 1896.



THE COMPLETE PATENTS OF NIKOLA TESLA

NIKOLA TESLA, OF NEW YORK, N.Y.

METHOD OF AND APPARATUS FOR PRODUCING CURRENTS OF HIGH FREQUENCY.

SPECIFICATION forming part of Letters Patent No. 568,179, dated September 22, 1896.
Application filed July 6, 1896. Serial No. 598,130. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Methods of and Apparatus for Producing Currents of High Frequency, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

The apparatus for producing electrical currents of very high frequency in which is embodied the invention of my present application involves as its chief element means for the periodic charging of a condenser or circuit possessing capacity by the energy of a given source and the discharge of the same through a circuit of low self-induction, whereby the rapid succession of impulses characteristic of a condenser discharge under such circumstances is made available for many practical and useful purposes.

The general arrangement of circuits and apparatus which I prefer for ordinary applications of this invention I have shown and described in an application filed by me April 22, 1896, Serial No. 588,534, as comprising a local circuit of high self-induction, connected with a source of supply, a condenser, a discharge-circuit of low self-induction, and a circuit-controller operating to alternately effect the charging of the condenser by the energy stored in the circuit of high self-induction and its discharge through that of low self-induction. I have shown, however, in the application referred to, as the source of current

the charging-current should bear a definite time relation to the period of the current, in order that the effective potential of the impulses charging the condenser may be as high as possible. I therefore provide, in case an alternating or equivalent electro-motive force be employed as the source of supply, a circuit-controller which will interrupt the charging-circuit at instants predetermined with reference to the variations of potential therein. The most practicable means for accomplishing this of which I am aware is to employ a synchronous motor connected with the source of supply and operating a circuit-controller which interrupts the charging-current at or about the instant of highest potential of each wave and permits the condenser to discharge the energy stored in it through its appropriate circuit. This apparatus, which may be considered as typical of the means employed for carrying out the invention, I have illustrated in the accompanying drawings.

The figures are diagrammatic illustrations of the system in slightly-modified forms, and will be described in detail in their order.

Referring to Figure 1, A designates any source of alternating or equivalent current, from which lead off mains A' A'. At any point where it is desired to produce the high-frequency currents a branch circuit B is taken off from the mains, and in order to raise the potential of the current a transformer is employed, represented by the primary C and secondary D. The circuit of the secondary includes the energizing-coils of a synchronous motor E and a circuit-controller, which, in the present instance, in Fig. 1 is shown as con-

THE COMPLETE PATENTS OF NIKOLA TESLA

at any determined point in its waves. It will be understood that by the proper relations of insulated and conducting segments and the
105 motor-poles the current may be interrupted twice in each complete wave at or about the points of highest potential. The self-induction of the circuit containing the motor and controller should be high, and the motor itself
110 will usually be constructed in such manner that no other self-induction device will be needed. The energy stored in this circuit is utilized at each break therein to charge a condenser K. With this object the terminals of the condenser
115 are connected to the two brushes H H or to points of the circuit adjacent thereto, so that when the circuit through the motor is interrupted the terminals of the motor-circuit will be connected with the condenser, whereby the lat-
120 ter will receive the high-potential inductive discharge from the motor or secondary circuit.

The condenser discharges into a circuit of low self-induction, one terminal of which is connected directly to a condenser-terminal and
125 the other to the brush H opposite to that connected with the other condenser-terminal, so that the discharge-circuit of the condenser will be completed simultaneously with the motor-circuit and interrupted while the motor-circuit
130 is broken and the condenser being charged.

The discharge-circuit contains a primary M of a few turns, and this induces in a secondary N impulses of high potential, which by reason of their great frequency are available for the
135 operation of vacuum-tubes P, single terminal-lamps R, and other novel and useful purposes.

It is obvious that the supply-current need not be alternating, provided it be converted or transformed into an alternating current before
140 reaching the controller. For example, the present improvements are applicable to various forms of rotary transformers, as is illustrated in Figs. 2 and 3.

E' designates a continuous-current motor, here represented as having four field-poles wound with coils E' in shunt to the armature. The line-wires B B connect with the brushes
145 b b, bearing on the usual commutator.

On an extension of the motor-shaft is a circuit-controller composed of a cylinder the

relatively to the cylinder, therefore, the alternating current delivered to the segments c c may be interrupted at any point in its waves.

While the brushes H H are on the
170 conducting-segments the current which they collect stores energy in a circuit of high self-induction formed by the wires f f, self-induction coils S S, the conductors B B, the brushes, and commutator. When this circuit is interrupted
175 by the brushes H H passing onto the insulating-segments of the controller, the high-potential discharge of this circuit charges the condensers K K, which then discharge through the circuit of low self-induction containing the primary M.
180 The secondary circuit N contains any devices, as P R, for utilizing the current.

The mechanical construction of the circuit-controller may be greatly varied, and in other respects the details shown and described are
185 merely given as typical illustrations of the nature and purpose of the invention.

What I claim is—

1. The method herein described of producing electric currents of high frequency, which
190 consists in generating an alternating current, charging a condenser thereby during determinate intervals of each wave of said current, and discharging the condenser through a circuit of low self-induction, as herein set forth.
195

2. The combination with a source of alternating current, a condenser, a circuit-controller adapted to direct the current during determinate intervals of each wave into the condenser for charging the same, and a circuit
200 of low self-induction into which the condenser discharges, as set forth.

3. The combination with a source of alternating current, a synchronous motor operated thereby, a circuit-controller operated by the
205 motor and adapted to interrupt the circuit through the motor at determinate points in each wave, a condenser connected with the motor-circuit and adapted on the interruption of the same to receive the energy stored
210 therein, and a circuit into which the condenser discharges, as set forth.

4. The combination with a source of alternating current, a charging-circuit in which the
215 source of said current is connected, a circuit-con-

THE COMPLETE PATENTS OF NIKOLA TESLA

(No Model.)

2 Sheets—Sheet 1.

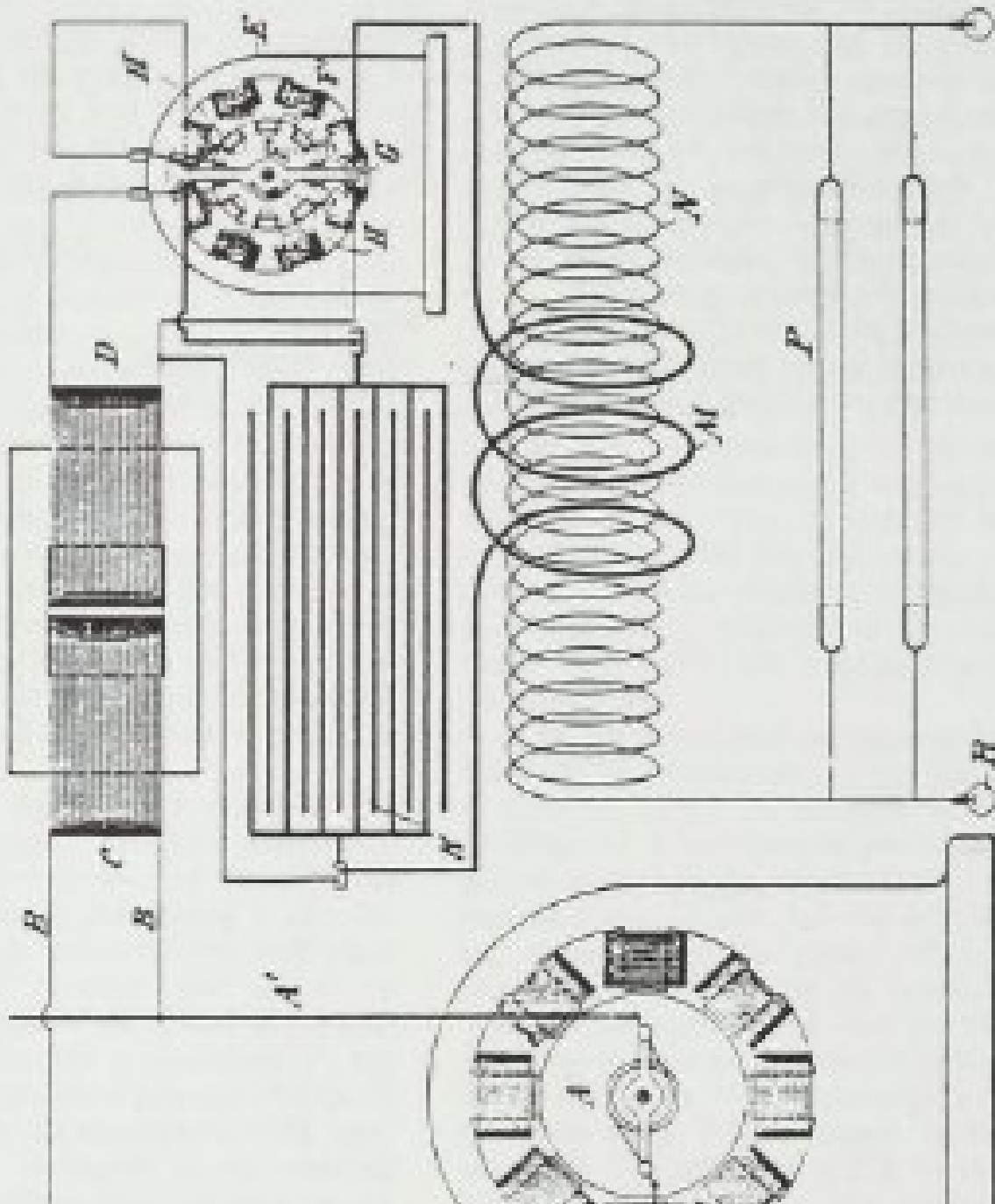
N. TESLA.

METHOD OF AND APPARATUS FOR PRODUCING CURRENTS OF
HIGH FREQUENCY.

No. 568,179.

Patented Sept. 22, 1896.

FIG. 1



THE COMPLETE PATENTS OF NIKOLA TESLA

(No Model.)

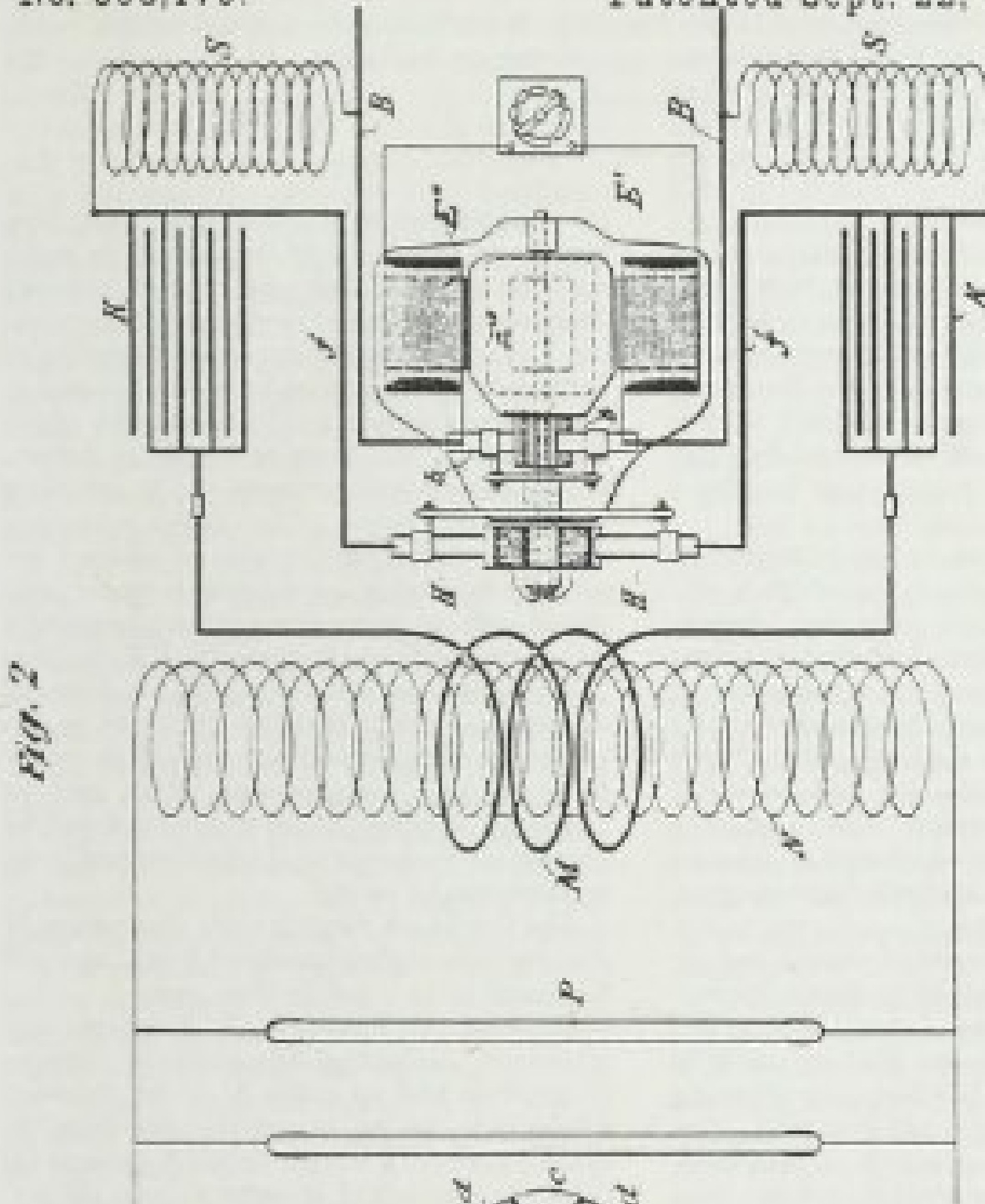
2 Sheets—Sheet 2.

N. TESLA.

METHOD OF AND APPARATUS FOR PRODUCING CURRENTS OF
HIGH FREQUENCY.

No. 568,179.

Patented Sept. 22, 1896.



THE COMPLETE PATENTS OF NIKOLA TESLA

or more pairs, as E E, diametrically opposite,
100 are integral or in electrical contact with the
body of the cylinder, so that when the control-
ler is in the position in which the two brushes
F F bear upon two of said segments E E the
circuit through the choking-coils B will be
105 closed. The segments D D are insulated, and
while shown in the drawings as of substantially
the same length of arc as the segments E E this
latter relation may be varied at will to regulate
the periods of charging and discharging.

110 The controller C is designed to be rotated
by any proper device, such, for example, as an
electromagnetic motor, as shown in Fig. 2,
receiving current either from the main source
or elsewhere. Around the controller C, or in
115 general in parallel therewith, is a condenser H,
and in series with the latter the primary K
of a transformer, the secondary L of which
constitutes the source of the currents of high
frequency which may be applied to many use-
120 ful purposes, as for electric illumination, the
operation of Crooke's tubes, or the production
of high vacua.

L indicates the circuit from the secondary,
which may be regarded as the working circuit.
125 A more convenient and simplified arrange-
ment of the apparatus is shown in Fig. 2. In
this case the small motor G, which drives the
controller, has its field-coils in derivation to
the main circuit, and the controller C and
130 condenser H are in parallel in the field-circuit
between the two coils. In such case the field-
coils M take the place of the choking-coils B.
In this arrangement, and in fact generally, it
is preferable to use two condensers or a con-
135 denser in two parts and to arrange the primary
coil of the transformer between them. The in-
terruptions of the field-circuit of the motor
should be so rapid as to permit only a partial
demagnetization of the cores. These latter,
140 however, should in this specific arrangement
be laminated.

The apparatus, as will now be seen, com-
prises, as essential elements, choking-coils, a
circuit-controller, means for rotating the same,
145 a condenser, and a transformer. These ele-
ments may be mechanically associated in any

limit myself to the use of the precise devices
commonly designated by such terms. For in-
stance, the choking-coil as a distinctive device
may be wholly dispensed with, provided the
circuit in which it must otherwise be placed
160 have a sufficiently high self-induction pro-
duced in other ways. So, too, the necessity of
a condenser, strictly speaking, is avoided when
the circuit itself possesses sufficient capacity to
accomplish the desired result. 165

Having now described my invention and
the manner in which the same is or may be
carried into practical effect, what I claim is—

1. The apparatus herein described for con-
verting direct currents into currents of high
170 frequency, comprising in combination a cir-
cuit of high self-induction, a circuit-controller
adapted to make and break such circuit, a con-
denser into which the said circuit discharges
when interrupted, and a transformer through
175 the primary of which the condenser discharges
as set forth.

2. The combination of a source of direct
current and a circuit therefrom, choking-coils
in said circuit, means for making and breaking
180 the circuit through said coils, a condenser
around the point of interruption in the said
circuit and a transformer having its primary
in circuit with the condenser as set forth.

3. The combination with a circuit of high
185 self-induction and means for making and
breaking the same, of a condenser around the
point of interruption in the said circuit, and
a transformer the primary of which is in the
condenser-circuit as described. 190

4. The combination with a circuit of direct
current and having a high self-induction, of a
circuit-controller for making and breaking said
circuit, a motor for driving the controller, a
condenser in a circuit connected with the first
195 around the point of interruption therein, and
a transformer the primary of which is in cir-
cuit with the condenser as set forth.

5. The combination with a circuit of direct
current, a controller for making and breaking
200 the same, a motor having its field-magnets in
said circuit and driving the said controller, a
condenser connected with the circuit around

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(No Model.)

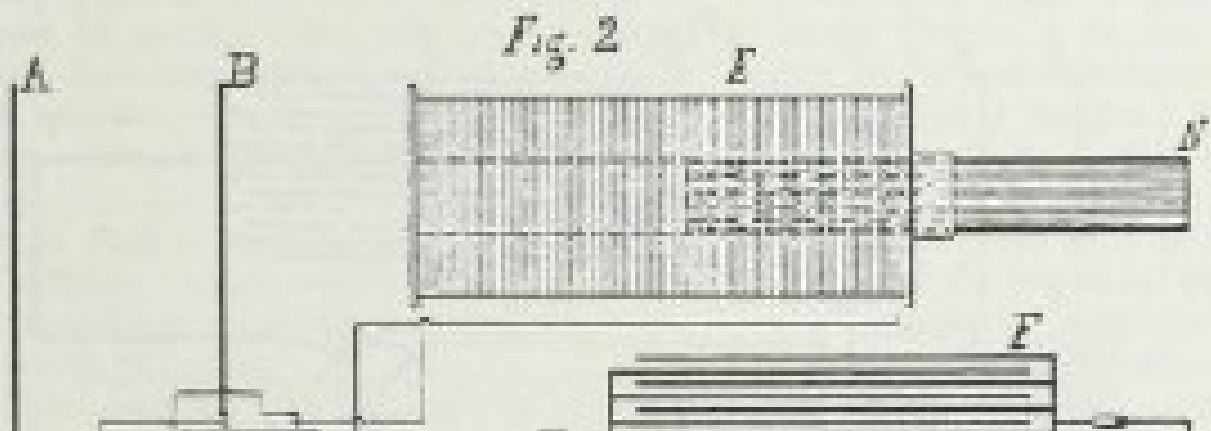
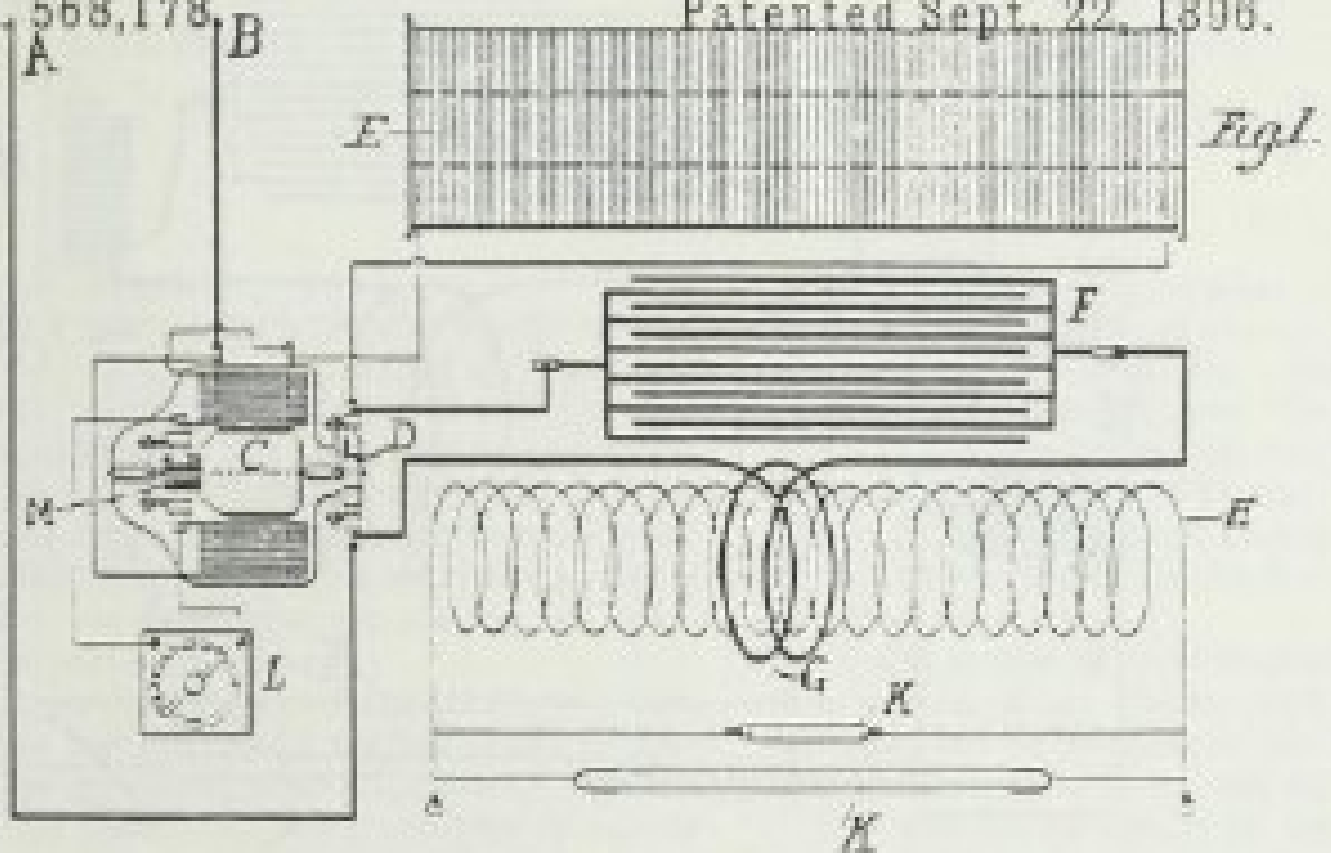
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N. TESLA.

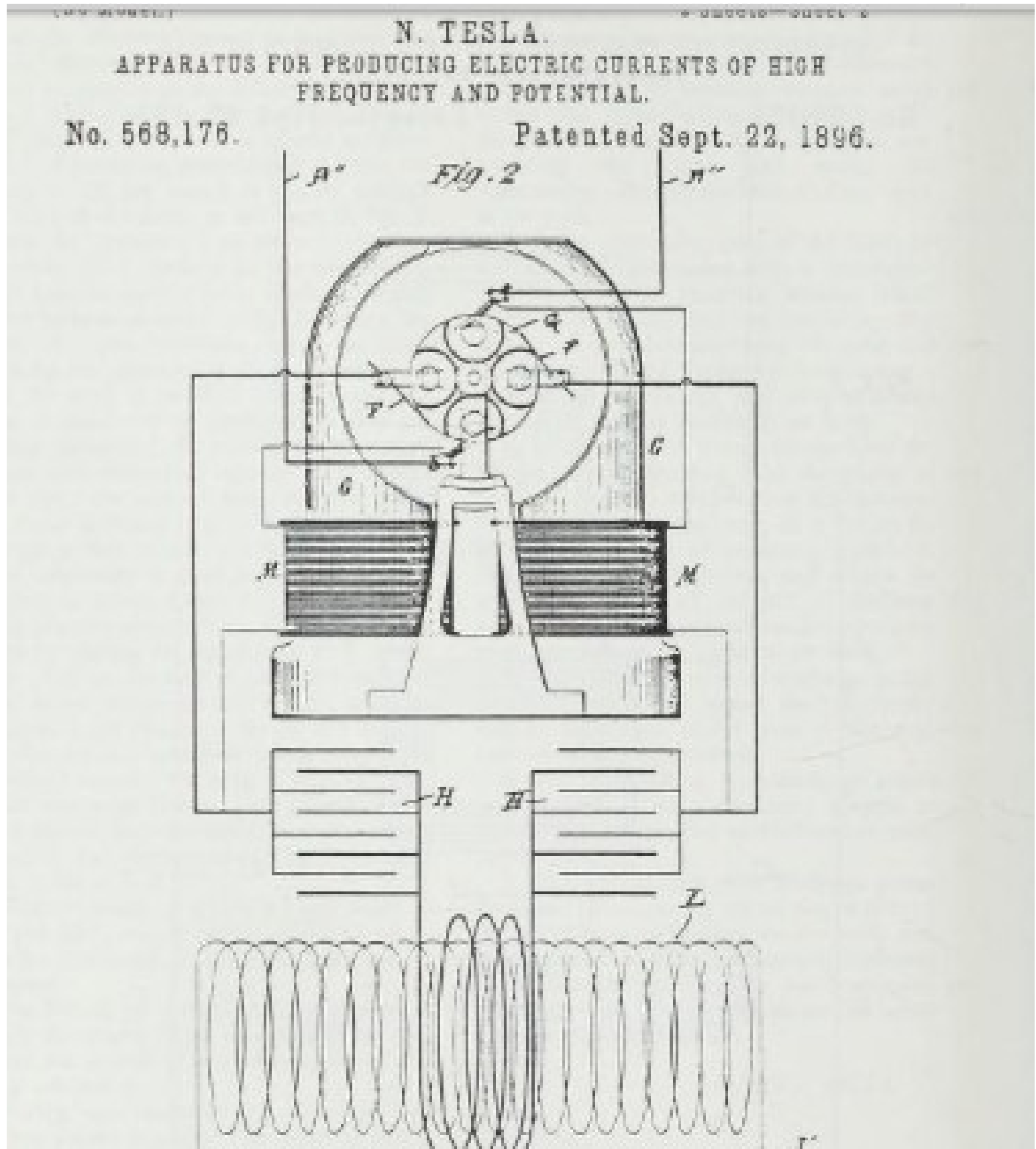
METHOD OF REGULATING APPARATUS FOR PRODUCING CURRENTS
OF HIGH FREQUENCY.

No. 568,178.

Patented Sept. 22, 1896.



THE COMPLETE PATENTS OF NIKOLA TESLA



THE COMPLETE PATENTS OF NIKOLA TESLA

APPARATUS FOR PRODUCING ELECTRIC CURRENTS OF HIGH FREQUENCY AND POTENTIAL.

SPECIFICATION forming part of Letters Patent No. 568,176, dated September 22, 1896.

Application filed April 22, 1896. Serial No. 568,554. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Apparatus for the Production of Electric Currents of High Frequency and Potential, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

The invention which forms the subject of my present application is embodied in an improvement on an electrical apparatus invented by me and described in prior Letters Patent, notably in United States Patents No. 462,418, dated November 3, 1891, and No. 454,622, dated June 23, 1891. This apparatus was devised for the purpose of converting and supplying electrical energy in a form suited for the production of certain novel electrical phenomena which require currents of higher frequency and potential than can readily or even possibly be developed by generators of the ordinary types or by such mechanical appliances as were theretofore known. The apparatus, as a whole, involves means for utilizing the intermittent or oscillating discharge of the accumulated electrical energy of a condenser or a circuit possessing capacity in what may be designated the "working" circuit, or that which contains the translating devices or those which are operated by such currents.

The object of my present improvements is to provide a simple, compact, and effective apparatus for producing these effects, but adapted more particularly for direct application to and use with existing circuits carrying direct currents, such as the ordinary municipal incandescent-lighting circuits. The way in which I accomplish this, so as to meet the

a branch or derived circuit across the mains from any ordinary source, I interpose a device or devices in the nature of a choking-coil in order to give to the circuit a high self-induction. I also provide a circuit-controller of any proper character that may be operated to make and break said circuit. Around the break or point of interruption I place a condenser or condensers to store the energy of the discharge-current, and in a local circuit and in series with such condenser I place the primary of a transformer, the secondary of which then becomes the source of the currents of high frequency. It will be apparent from a consideration of the conditions involved that were the condenser to be directly charged by the current from the source and then discharged into the working circuit a very large capacity would ordinarily be required, but by the above arrangement the current of high electromotive force which is induced at each break of the main circuit furnishes the proper current for charging the condenser, which may therefore be small and inexpensive. Moreover, it will be observed that since the self-induction of the circuit through which the condenser discharges, as well as the capacity of the condenser itself, may be given practically any desired value, the frequency of the discharge-current may be adjusted at will.

The object sought in this invention may be realized by specifically different arrangements of apparatus, but in the drawings hereto annexed I have illustrated forms which are typical of the best and most practicable means for carrying out the invention of which I am at present aware.

Figure 1 is a diagrammatic illustration of the apparatus, and Fig. 2 a modification of the same.

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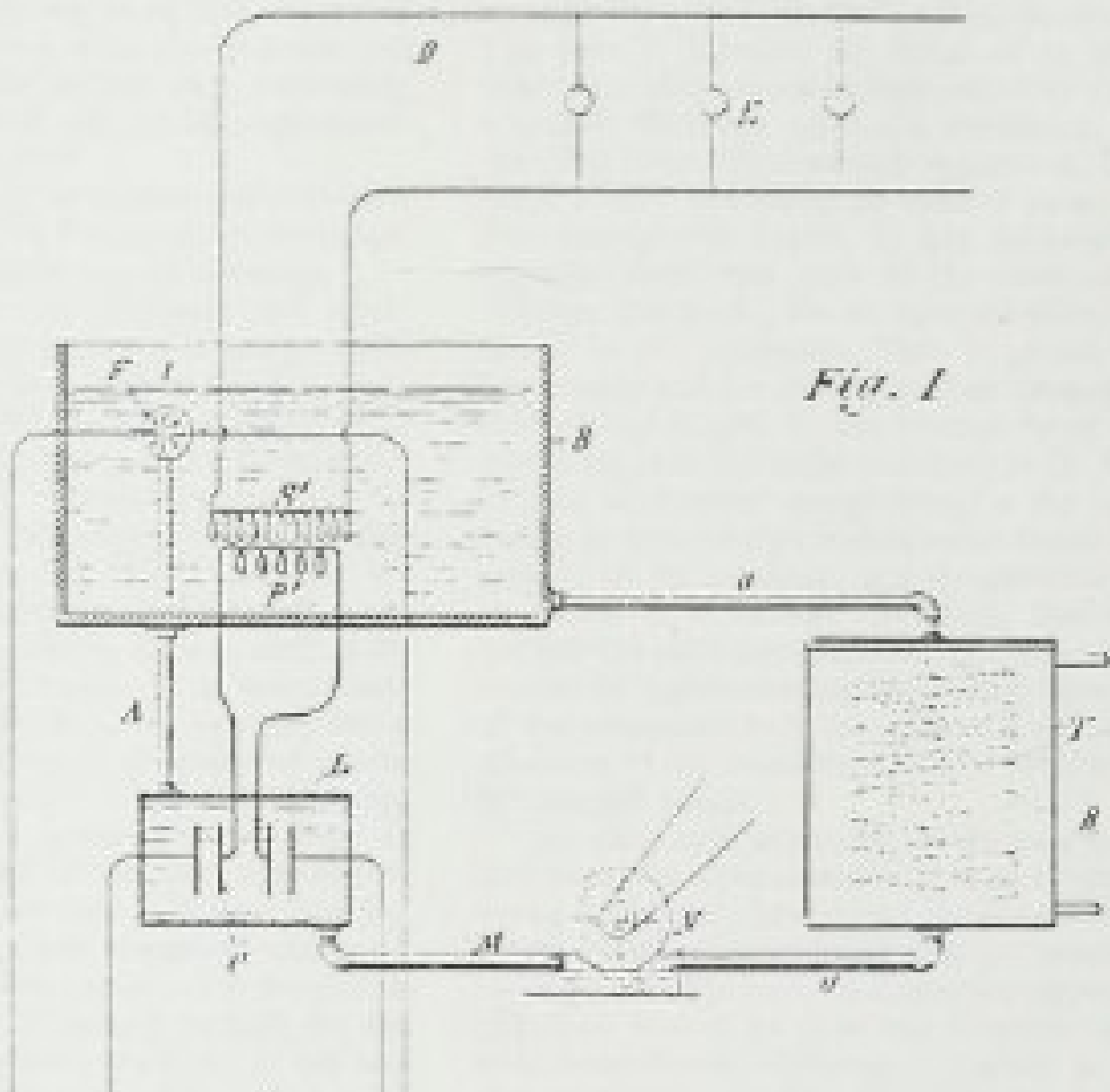
Case Model 1

N. TESLA.

MEANS FOR GENERATING ELECTRIC CURRENTS

No. 514,168.

Patented Feb. 6, 1894.



THE COMPLETE PATENTS OF NIKOLA TESLA

NIKOLA TESLA, OF NEW YORK, N. Y.

MEANS FOR GENERATING ELECTRIC CURRENTS.

SPECIFICATION forming part of Letters Patent No. 514,168, dated February 6, 1894.

Application filed August 2, 1893. Serial No. 982,198. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have
5 invented certain new and useful Improvements in Means for Generating Electric Currents, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

10 The invention, subject of my present application is an improvement applicable more especially to the method or system of generating and utilizing electrical energy, heretofore discovered by me, and more fully set forth in
15 Letters Patent No. 454,622, of June 23, 1891, and No. 462,418, of November 3, 1891, and which involves the maintenance of an intermittent or oscillatory discharge of a condenser or circuit of suitable capacity into a working
20 circuit containing translating devices. In systems of this character when the high frequency of the currents employed is due to the action of a disruptive or intermittent discharge across an air gap or break at some point of the cir-
25 cuit, I have found it to be of advantage not only to break up or destroy the least tendency to continuity of the arc or discharge, but also to control the period of the re-establishment of the same, and from investigations made by
30 me with this object in view I have found that greatly improved results are secured by causing the discharge to take place in and through an insulating liquid, such as oil, and instead of allowing the terminal points of the break to
35 remain at a uniform distance from each other, to vary such distance by bringing them period-

maintaining the flow or circulation of the insulating medium past the points of discharge, 50
and I take advantage of the presence of such mechanism to accomplish a further and beneficial result which is the maintenance of a flow or circulation of the insulating liquid in which 55
I immerse the converter coils used for raising the potential of the current, and also the condenser plates when such are required and used. By this means the insulating liquid surrounding the said coils and plates may be prevented from heating, either by its circulation 60
alone or by the application to it while in motion of a cooling medium, and its requisite qualities preserved for an indefinite time.

Broadly considered the plan contemplated is entirely independent of the special means 65
for carrying it into execution, but in illustration of the preferred manner in which the invention is or may be carried out, I now refer to the drawings which are hereto annexed. 70

Figure 1 is a diagram of the system and devices employed by me. Fig. 2 is a sectional view of a detail of mechanism.

G represents an electric generator, as for instance, an ordinary alternator, in the circuit 75
of which is the primary P of a transformer, of which S represents the secondary, which is usually of much longer and finer wire than the primary. To the secondary circuit, if it have not of itself sufficient capacity for the 80
purpose herein contemplated, are connected the plates of a condenser C, and at any point in said circuit is a break or gap at which occurs the disruptive discharge. In a portion of the secondary circuit, preferably in series with 85

THE COMPLETE PATENTS OF NIKOLA TESLA

(No Model.)

2 Sheets—Sheet 2.

N. TESLA.

ALTERNATING ELECTRIC CURRENT GENERATOR.

No. 447,921.

Patented Mar. 10, 1891.

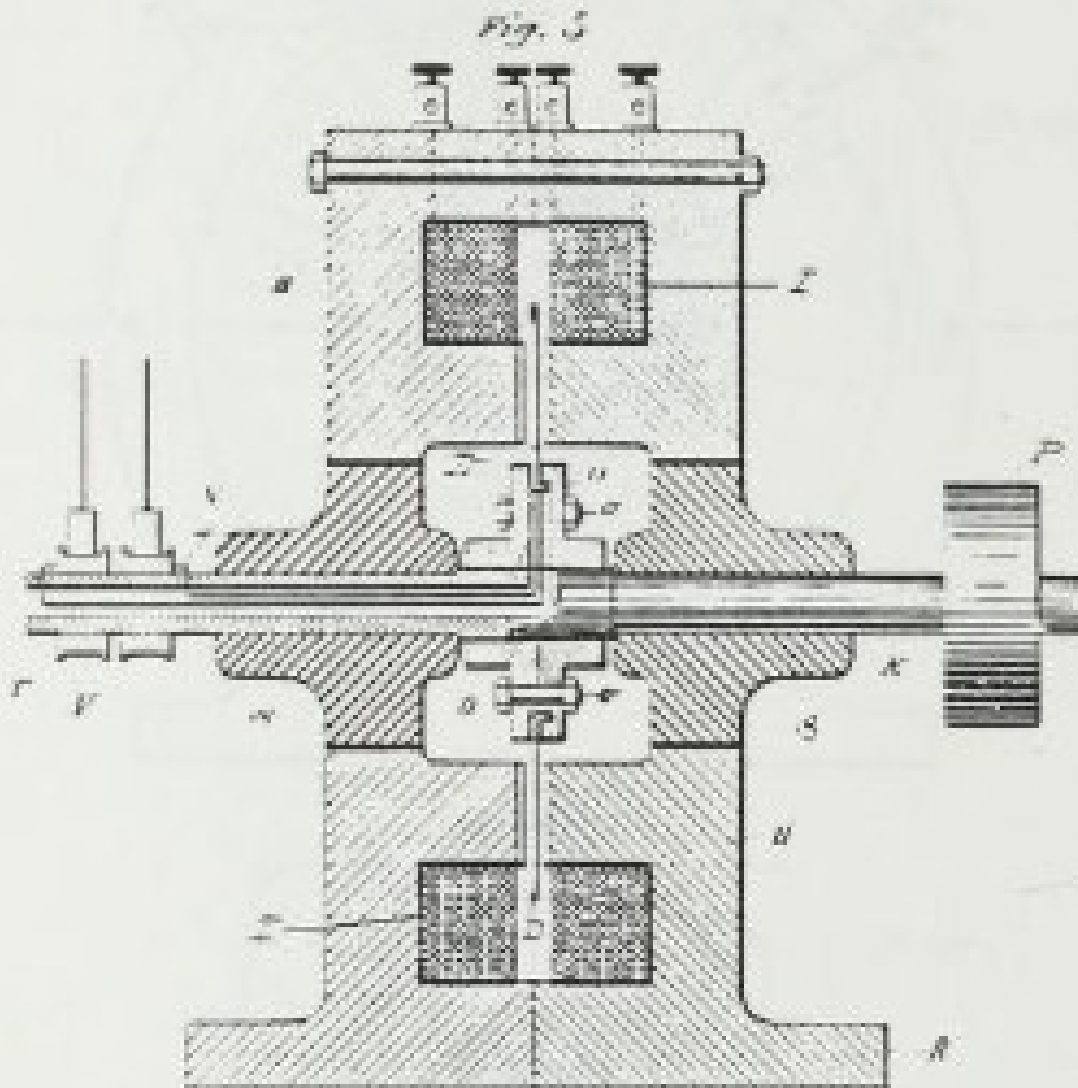


Fig. 4

THE COMPLETE PATENTS OF NIKOLA TESLA

NIKOLA TESLA, OF NEW YORK, N. Y.

ALTERNATING-ELECTRIC-CURRENT GENERATOR.

SPECIFICATION forming part of Letter Patent No. 447,921, dated March 10, 1891.

Application filed November 15, 1890. Serial No. 371,554. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria, from Smiljan, Lika, border country of Austria-Hungary, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Alternating-Current Machines, of which the following is a specification, reference being had to the accompanying drawings.

In the systems of distribution of electrical energy from alternating-current generators in present use the generators give ordinarily from one to three hundred alternations of current per second. I have recognized and demonstrated in practice that it is of great advantage, on many accounts, to employ in such systems generators capable of producing a very much greater number of alternations per second—say fifteen thousand per second or many more. To produce such a high rate of alternation, it is necessary to construct a machine with a great number of poles or polar projections; but such construction, on this account, in order to be efficient, is rendered difficult. If an armature without polar projections be used, it is not easy to obtain the necessary strength of field, mainly in consequence of the comparatively great leakage of the lines of force from pole to pole. If, on the contrary, an armature-core formed or provided with polar projections be employed, it is evident that a limit is soon reached at which the iron is not economically utilized, being incapable of following without considerable loss the rapid reversals of

a great many projections or serrations, the points of which in one side or polar face are preferably exactly opposite those in the other. Between the faces so formed I mount or support the armature coil or coils and provide either for rotating the field-magnet or the armature, or both, and I arrange the said armature-coil or conductor so that it will be symmetrically disposed with respect to the field—that is to say, so that when one portion of the conductor is passing through the strongest portion of the field the other portion, which forms the return for the former, is passing through the weakest points or parts of the field. The strongest points of the field, it will be understood, are those between the projections or points on the polar faces, while the weakest points lie midway between them.

A field-magnet, when constructed as above described, produces, when the energizing-coil is traversed by a continuous current, a field of great strength, and one which may be made to vary greatly in intensity at points not farther distant from one another than the eighth of an inch. In a machine thus constructed there is comparatively little of that effect which is known as "magnetic leakage," and there is also but a slight armature reaction. Either the armature-conductor or the field-magnet may be stationary while the other rotates, and as it is often desirable to maintain the conductors stationary and to rotate the field-magnet I have made a special modification of the construction of the machine for this purpose, and with a view in such case

THE COMPLETE PATENTS OF NIKOLA TESLA

No Model.

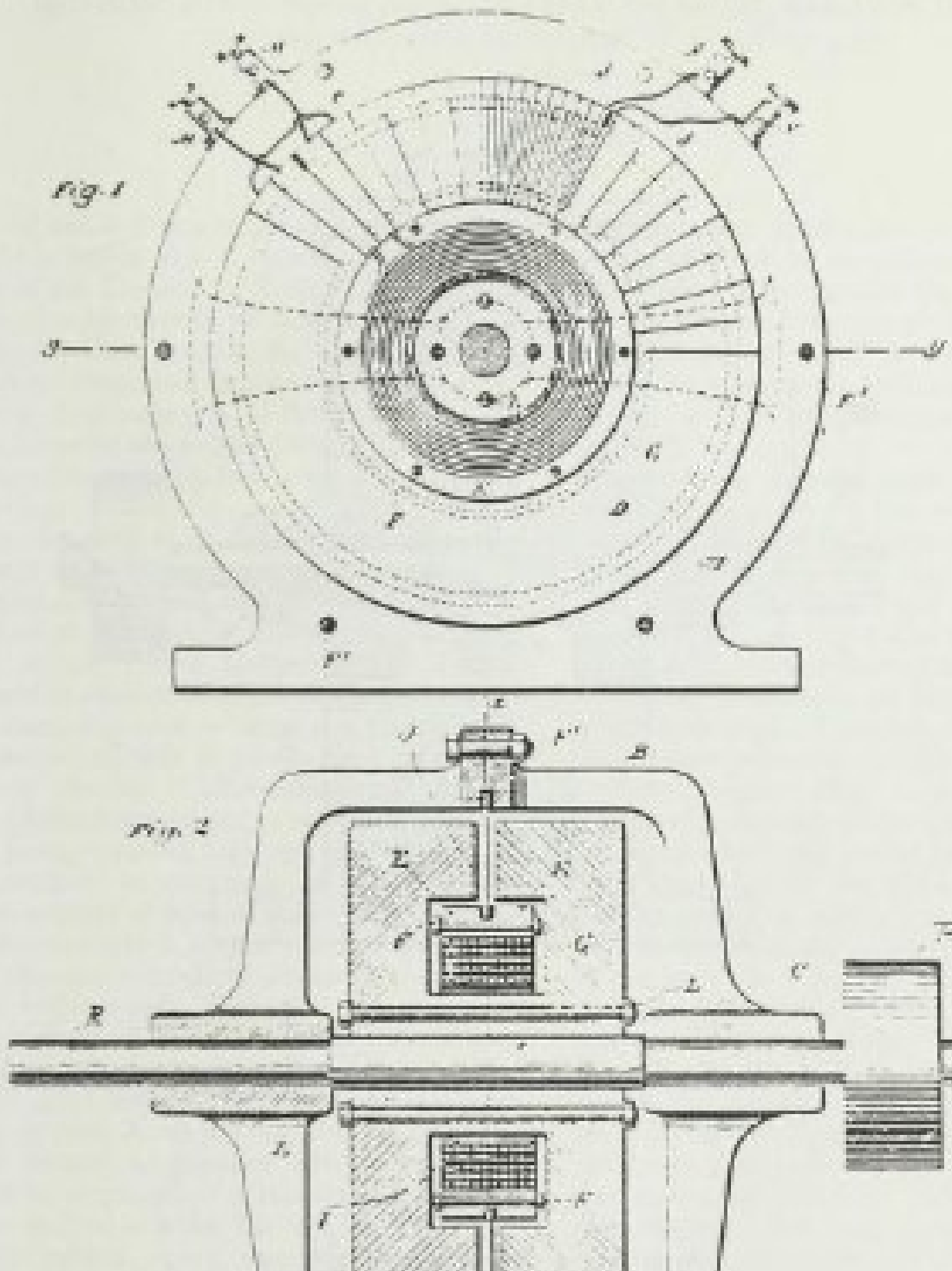
Sheet—Sheet 1

N. TESLA.

ALTERNATING ELECTRIC CURRENT GENERATOR.

No. 447,921.

Patented Mar. 10, 1891.



THE COMPLETE PATENTS OF NIKOLA TESLA

assumed number of convolutions or turns is the same, viz., one thousand, then the potential difference between any two adjacent points in
105 A and B will be fifty volts, and as the capacity effect is proportionate to the square of this difference, the energy stored in the coil as a whole will now be two hundred and fifty thousand as great. Following out this principle,
110 I may wind any given coil either in whole or in part, not only in the specific manner herein illustrated, but in a great variety of ways, well-known in the art, so as to secure between adjacent convolutions such potential
115 difference as will give the proper capacity to neutralize the self-induction for any given current that may be employed. Capacity secured in this particular way possesses an additional advantage in that it is evenly distributed, a
120 consideration of the greatest importance in many cases, and the results, both as to efficiency and economy, are the more readily and easily obtained as the size of the coils, the potential difference, or frequency of the currents are increased.

Coils composed of independent strands or conductors wound side by side and connected in series are not in themselves new, and I do not regard a more detailed description of the
130 same as necessary. But heretofore, so far as I am aware, the objects in view have been essen-

ential in winding, have not been appreciated or taken advantage of.

135

In carrying out my invention it is to be observed that certain facts are well understood by those skilled in the art, viz: the relations of capacity, self-induction, and the frequency and potential difference of the current. What
140 capacity, therefore, in any given case it is desirable to obtain and what special winding will secure it, are readily determinable from the other factors which are known.

What I claim as my invention is—

145

1. A coil for electric apparatus the adjacent convolutions of which form parts of the circuit between which there exists a potential difference sufficient to secure in the coil a capacity capable of neutralizing its self-induction, as
150 hereinbefore described.

2. A coil composed of contiguous or adjacent insulated conductors electrically connected in series and having a potential difference of such value as to give to the coil
155 as a whole, a capacity sufficient to neutralize its self-induction, as set forth.

NIKOLA TESLA.

Witnesses:

ROBT. F. GAYLORD,
PARKER W. PAGE.

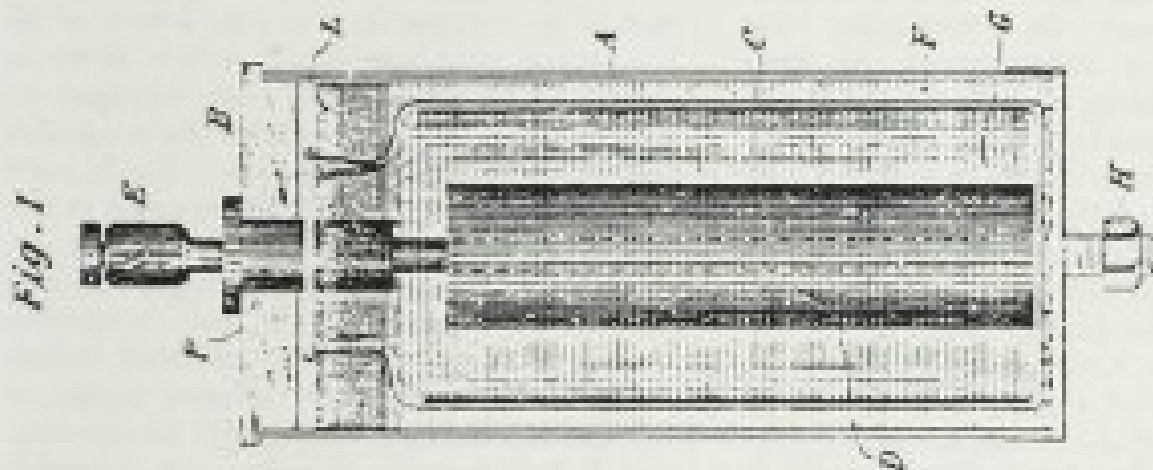
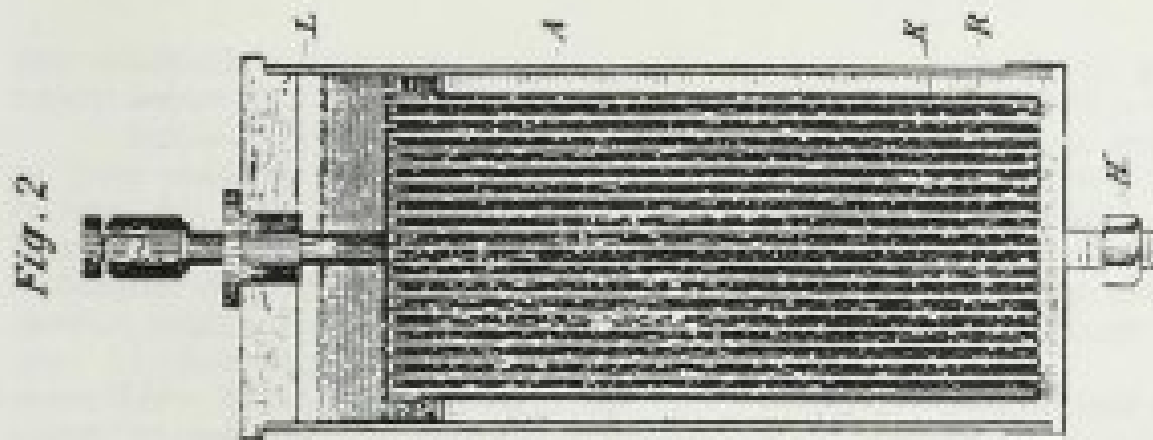
THE COMPLETE PATENTS OF NIKOLA TESLA

(No Model.)

N. TESLA.
ELECTRICAL CONDENSER.

No. 567,818.

Patented Sept. 15, 1896.



THE COMPLETE PATENTS OF NIKOLA TESLA

(No Model.)

N. TESLA.

ELECTRICAL TRANSFORMER OR INDUCTION DEVICE.

No. 433,702.

Patented Aug. 5, 1890.

Fig. 1

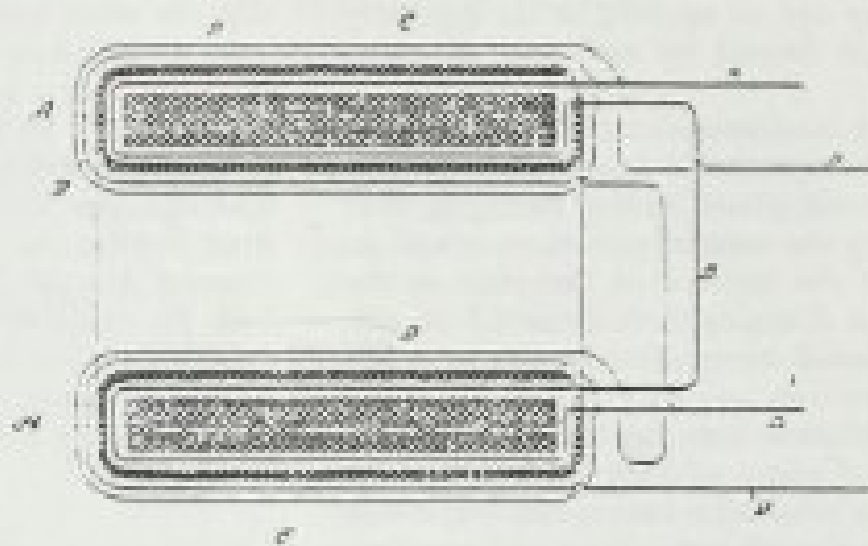
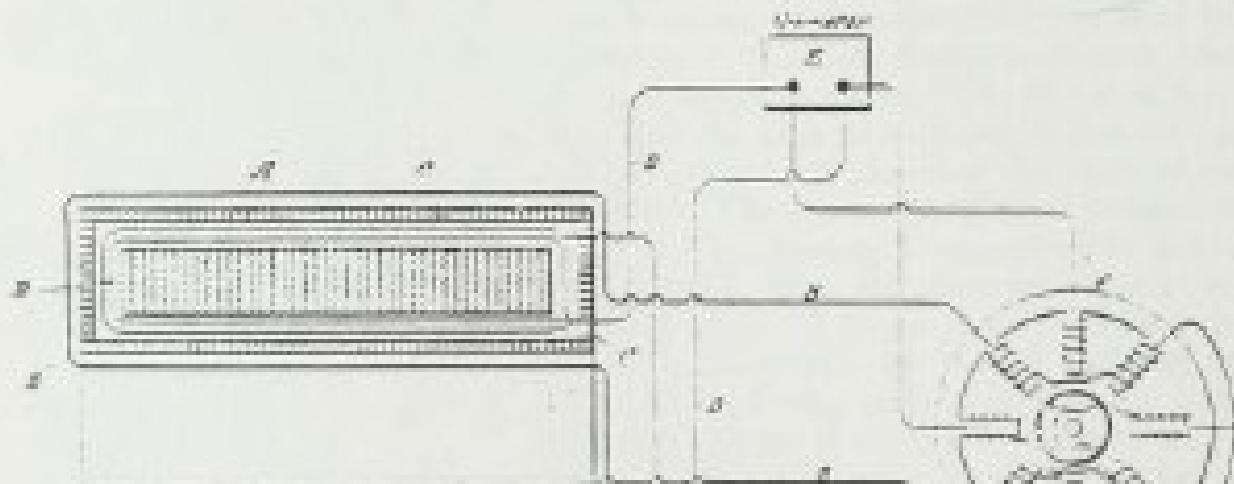


Fig. 2



THE COMPLETE PATENTS OF NIKOLA TESLA

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR TO THE TESLA
ELECTRIC COMPANY, OF SAME PLACE.

ELECTRICAL TRANSFORMER OR INDUCTION DEVICE.

SPECIFICATION forming part of Letters Patent No. 433,702, dated August 5, 1890.

Application filed March 26, 1890. Serial No. 345,390. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria-Hungary, from Smiljan, Lika, border country of Austria-Hungary, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electrical Transformers or Induction Devices, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

This invention is an improvement in electrical transformers or converters, and has for its main objects the provision of means for securing, first, a phase difference between the primary and secondary currents adapted to the operation of my alternating-current motors and other like purposes, and, second, a constant current for all loads imposed upon the secondary.

In transformers as constructed now and heretofore it will be found that the electromotive force of the secondary very nearly coincides with that of the primary, being, however, of opposite sign. At the same time the currents, both primary and secondary, lag behind their respective electro-motive forces; but as this lag is practically or nearly the same in the case of each it follows that the maximum and minimum of the primary and secondary currents will nearly coincide, but differ in sign or direction, provided the secondary be not loaded or if it contain devices having the property of self-induction. On the other hand, the lag of the primary behind the impressed

which, however produced, pass through the two circuits of the motor, a difference of phase of ninety degrees; or, in other words, the current in one circuit should be maximum when that in the other circuit is minimum. To more perfectly attain to this condition I obtain or secure an increased retardation of the secondary current in the following manner: Instead of bringing the primary and secondary coils or circuits of a transformer into the closest possible relations, as has hitherto been done, I protect in a measure the secondary from the inductive action or effect of the primary by surrounding either the primary or the secondary with a comparatively thin magnetic shield or screen. Under these conditions or circumstances, as long as the primary current has a small value, the shield protects the secondary; but as soon as the primary current has reached a certain strength, which is arbitrarily determined, the protecting magnetic shield becomes saturated and the inductive action upon the secondary begins. It results, therefore, that the secondary current begins to flow at a certain fraction of a period later than it would without the interposed shield, and since this retardation may be obtained without necessarily retarding the primary current also, an additional lag is secured, and the time interval between the maximum or minimum periods of the primary and secondary currents is increased. I have further discovered that such a transformer may, by properly proportioning its several elements and determining in a manner well understood the proper relations be-

THE COMPLETE PATENTS OF NIKOLA TESLA

(No Model.)

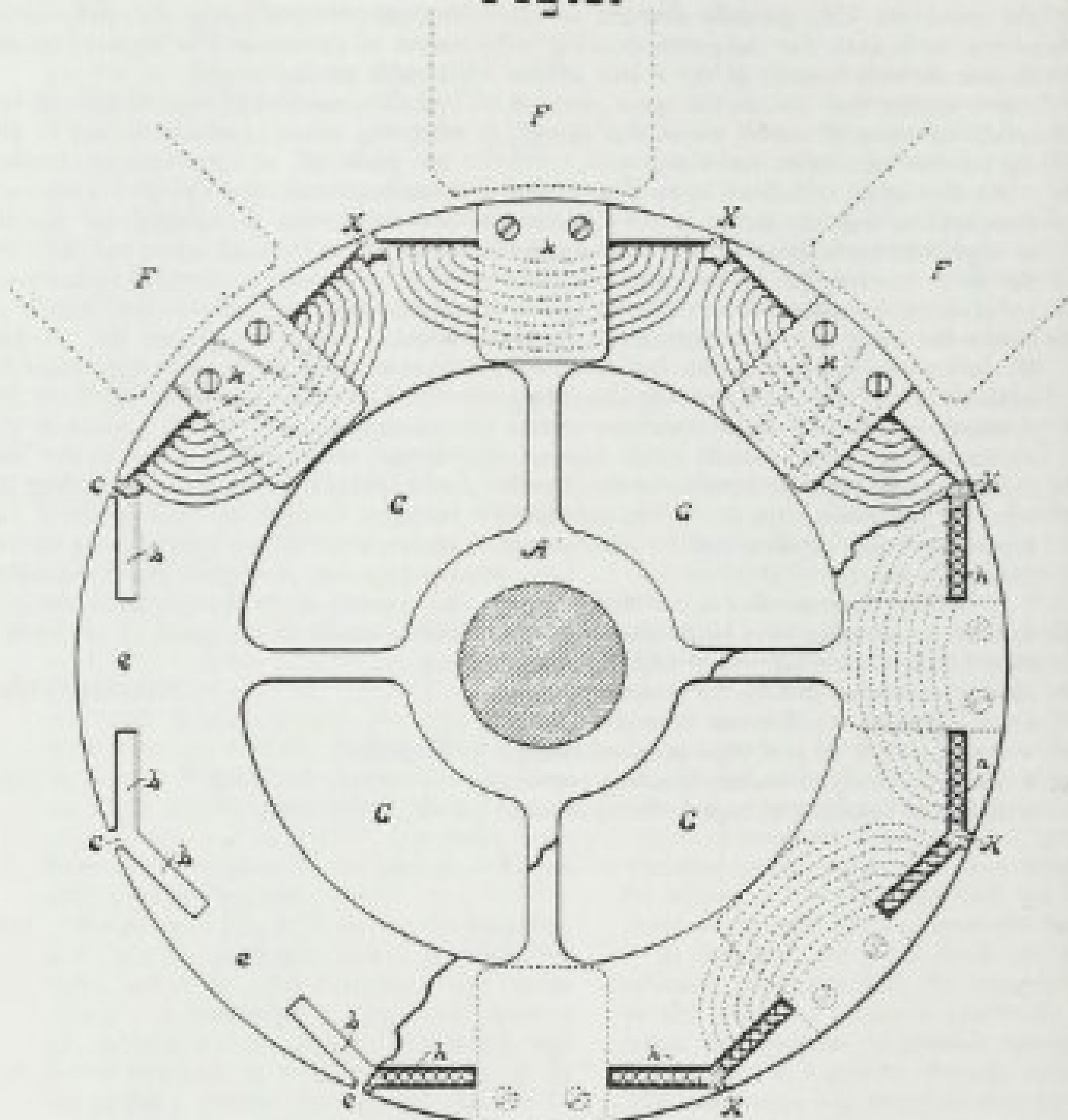
2 Sheets—Sheet 1

A. SCHMID & N. TESLA.
ARMATURE FOR ELECTRIC MACHINES.

No. 417,794.

Patented Dec. 24, 1889.

Fig. 1.



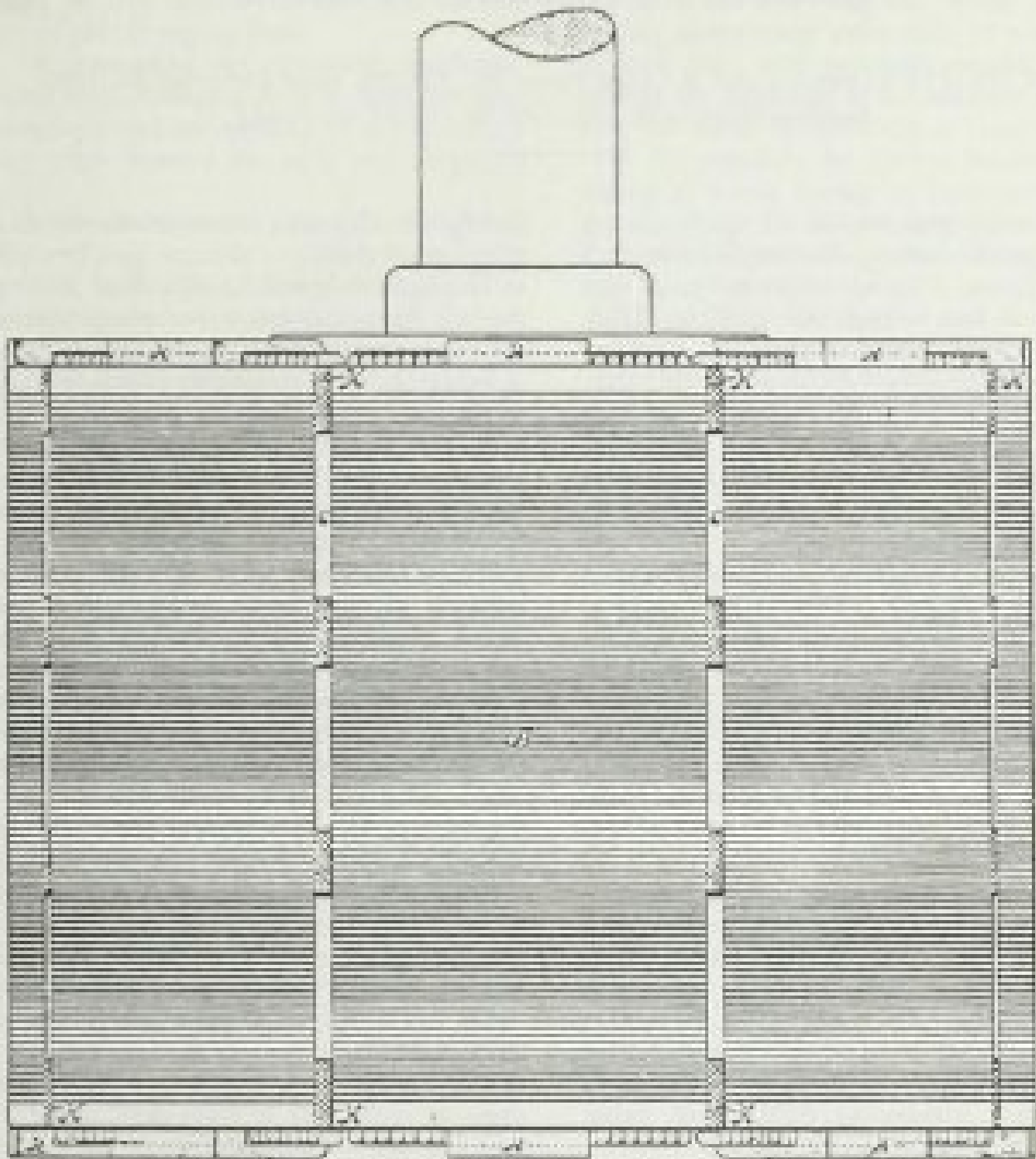
THE COMPLETE PATENTS OF NIKOLA TESLA

A. SCHMID & N. TESLA.
ARMATURE FOR ELECTRIC MACHINES.

No. 417,794.

Patented Dec. 24, 1889.

Fig. 2.



THE COMPLETE PATENTS OF NIKOLA TESLA

(No Model.)

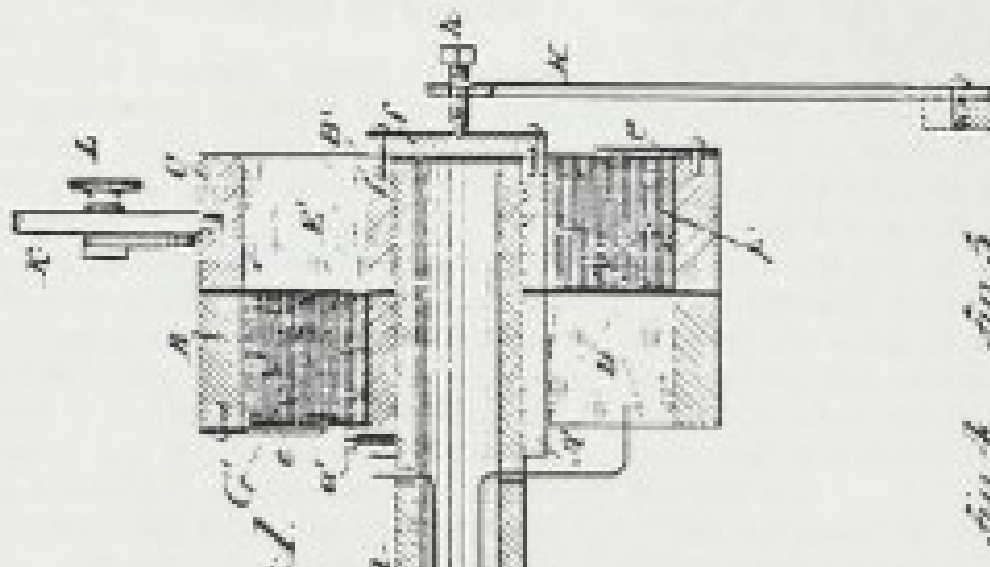
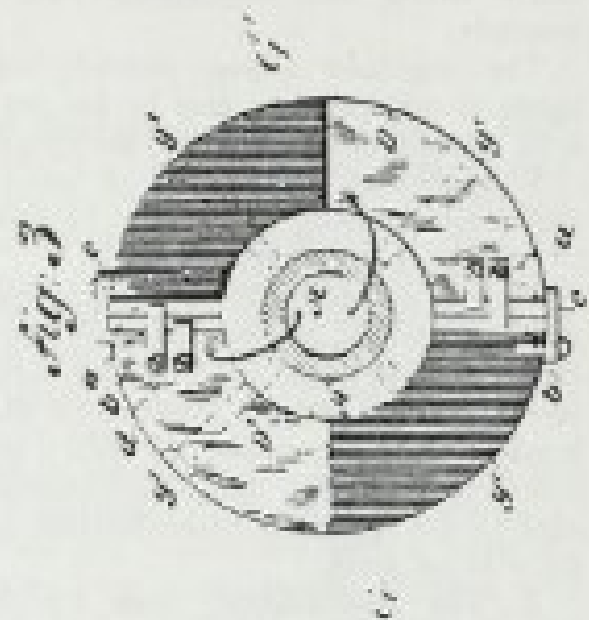
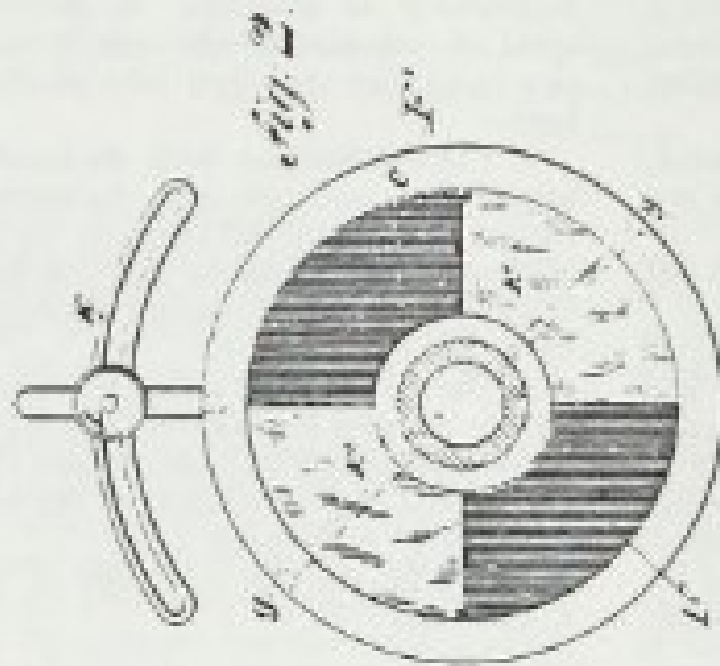
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N. TESLA.

COMMUTATOR FOR DYNAMO ELECTRIC MACHINES.

No. 382,845.

Patented May 15, 1888.



THE COMPLETE PATENTS OF NIKOLA TESLA

(No Model)

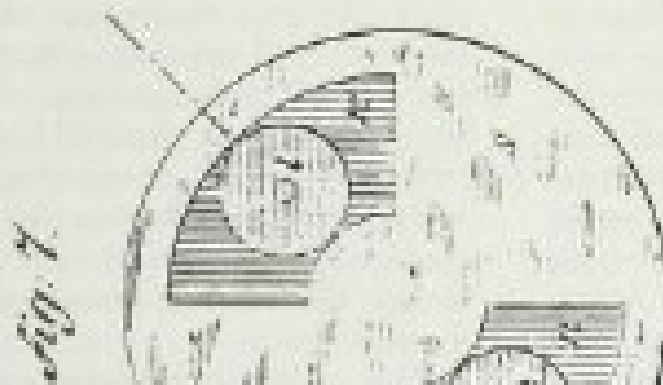
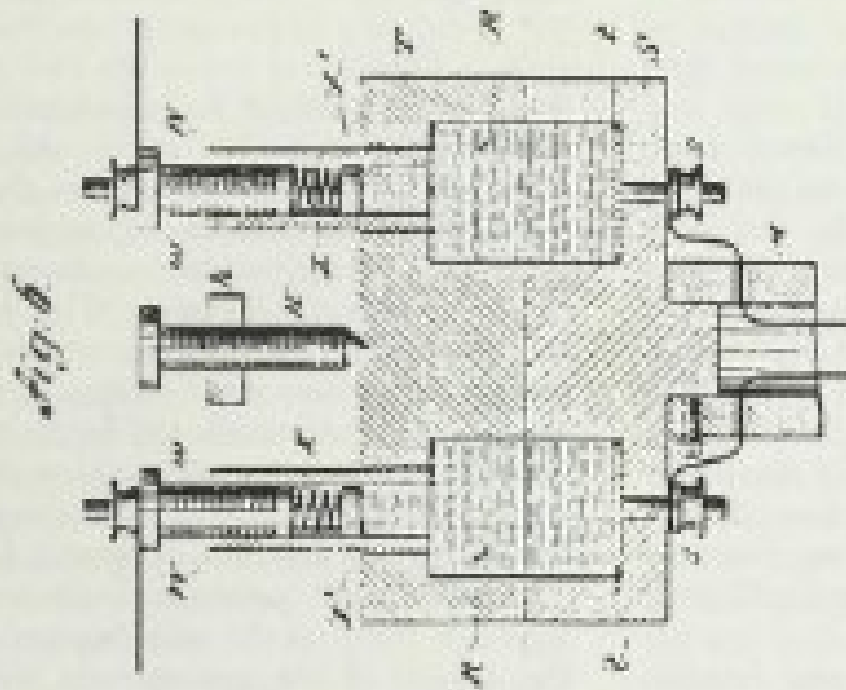
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N. TESLA.

COMMUTATOR FOR DYNAMO ELECTRIC MACHINES.

No. 382,845.

Patented May 15, 1888.



THE COMPLETE PATENTS OF NIKOLA TESLA

NIKOLA TESLA, OF SMILJAN LIKA, AUSTRIA-HUNGARY, ASSIGNOR TO THE TESLA ELECTRIC LIGHT AND MANUFACTURING COMPANY, OF RAHWAY, NEW JERSEY.

REGULATOR FOR DYNAMO-ELECTRIC MACHINES.

SPECIFICATION forming part of Letters Patent No. 350,954, dated October 19, 1886.

Application filed January 14, 1886. Serial No. 188,559. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, from Smiljan Lika, border country of Austria-Hungary, have invented certain Improvements in Dynamo-Electric Machines, of which the following is a specification.

In other applications I have shown the commutator of a dynamo-machine with the main brushes connected in an electric circuit, and one or more auxiliary brushes serving to shunt a part or the whole of the field-coils, the regulation of the current being effected by shifting the respective brushes automatically upon the commutator in proportion to the varying resistances of the circuit.

My present invention relates to the mechanical devices which I employ to effect the shifting of the brushes.

My invention is clearly shown in the accompanying drawings, in which Figure 1 is an elevation of the regulator with the frame partly in section; and Fig. 2 is a section at the line *xx*, Fig. 1.

C is the commutator; B and B', the brush-holders, B carrying the main brushes *a a'* and B' the auxiliary or shunt brushes *b b'*. The axis of the brush-holder B is supported by two pivot-screws, *p p*. The other brush-holder, B', has a sleeve, *d*, and is movable around the axis of the brush-holder B. In this way both brush-holders can turn very freely, the friction of the parts being reduced to a minimum. Over the brush-holders is mounted the solenoid S, which rests upon a forked column, *c*. This column also affords a support for the pivots *p p*, and is fastened upon a solid bracket or projection, P, which extends from the base of the machine, and is preferably cast in one piece with the base. The brush-holder B is

precision the core I is provided with a small iron screw, *r'*. The core being first brought very nearly in the required position relatively to the solenoid by means of the screw *r*, the small screw *r'* is then adjusted until the magnetic attraction upon the core is the same when the core is in any position. A convenient stop, *s*, serves to limit the upward movement of the iron core.

To check somewhat the movement of the core I, a dash-pot, K, is used. The piston L of the dash-pot is provided with a valve, V, which opens by a downward pressure and allows an easy downward movement of the iron core I, but closes and checks the movement of the core when the same is pulled up under the action of the solenoid.

To balance the opposing forces, the weight of the moving parts, and the pull exerted by the solenoid upon the iron core, the weights W W may be used. The adjustment is such that when the solenoid is traversed by the normal current it is just strong enough to balance the downward pull of the parts.

The electrical circuit-connections are substantially the same, as indicated in my former applications, the solenoid being in series with the circuit when the translating devices are in series and in a shunt when the devices are in multiple arc.

The operation of the device is as follows: When upon a decrease of the resistance of the circuit or some other reason the current is increased, the solenoid S gains in strength and pulls up the iron core I, thus shifting the main brushes in the direction of rotation and the auxiliary brushes in the opposite way. This diminishes the strength of the current until

THE COMPLETE PATENTS OF NIKOLA

TESLA

easy downward movement of the iron core, but checks its movement when it is drawn up by the solenoid. Such an arrangement has the advantage that a great number of lights may
105 be put on without diminishing the light-power of the lamps in the circuit, as the brushes assume at once the proper position. When lights are cut out, the dash pot acts to retard the movement; but if the current is
110 considerably increased the solenoid gets abnormally strong and the brushes are shifted instantly.

The regulator being properly adjusted, lights or other devices may be put on or out
115 with scarcely any perceptible difference.

It is obvious that instead of the dash-pot any other retarding device may be used.

I claim as my invention—

1. The combination, with the main and
120 auxiliary brushes, of two brush-holders, an axis fastened to one of the brush-holders, supporting-screws for the same, a support for the other brush-holder surrounding the axis, a solenoid, a core for the same, and links connecting the
125 core to the respective brush-holders, substantially as set forth.

2. The combination, with the brushes, brush-holders, and the axis upon which the brush-holders swing, of a solenoid and core,
130 connections from the same to the brush-holders, and an adjusting-screw to limit the movements of the core, substantially as set forth.

connection from the core to the brush-holders, 135 and an iron screw at the inner end of the core to adjust the action of the magnetism on the core, substantially as set forth.

4. The combination, with the brushes, the brush-holders and their axes, of a solenoid and 140 core, and connections to move the brush-holders, and a dash-pot provided with a valve, substantially as described, to diminish the speed of movement of the core in one direction more than the other, substantially as set 145 forth.

5. The combination, with the brushes, the brush-holders and their axes, of a solenoid and core, and connections to move the brush-holders, and a dash-pot to diminish the speed 150 of movement of the core, substantially as set forth.

6. The combination, with the brush-holders and the solenoid and core, of links connecting to the holders, and a screw to adjust the posi- 155 tion of the core in relation to the solenoid, substantially as set forth.

Signed by me this 12th day of January, A. D. 1886.

NIKOLA TESLA.

Witnesses:

GEO. T. PIERCEY,
WILLIAM G. MOTT.

THE COMPLETE PATENTS OF NIKOLA TESLA

The field-helices may be wound in the same direction, or a part may be wound in opposite directions.

105 The connection between the helices and the auxiliary brush or brushes may be made by a wire of small resistance, or a resistance may be interposed (R, Fig. 5) between the point x and the auxiliary brush or brushes to divide the sensitiveness when the brushes are
110 adjusted.

I am aware that it is not new to use auxiliary brushes on the commutator, and that auxiliary brushes have been connected to the field helices; but I am not aware that the helices of
115 a series dynamo have been shunted by means of auxiliary brushes, and that the relative position of the respective brushes has been varied for the purpose of regulating the current developed by the machine.

120 In instances where auxiliary brushes have been used in connection with the field-helices

in my invention the auxiliary brush receives current only when the normal electrical condi- 125 tions of the circuit are disturbed.

I claim as my invention—

The combination, with the commutator and main brushes and one or more auxiliary brushes, of the field-helices in the main cir- 130 cuits and one or more shunt-connections from the field-helices to the auxiliary brushes, the relative positions upon the commutator of the respective brushes being adjustable, for the pur-
135 pose set forth.

Signed by me this 16th day of May,
A. D. 1885.

NIKOLA TESLA.

Witnesses:

GEO. T. PIERCEY,

WALLACE L. SERRELL.

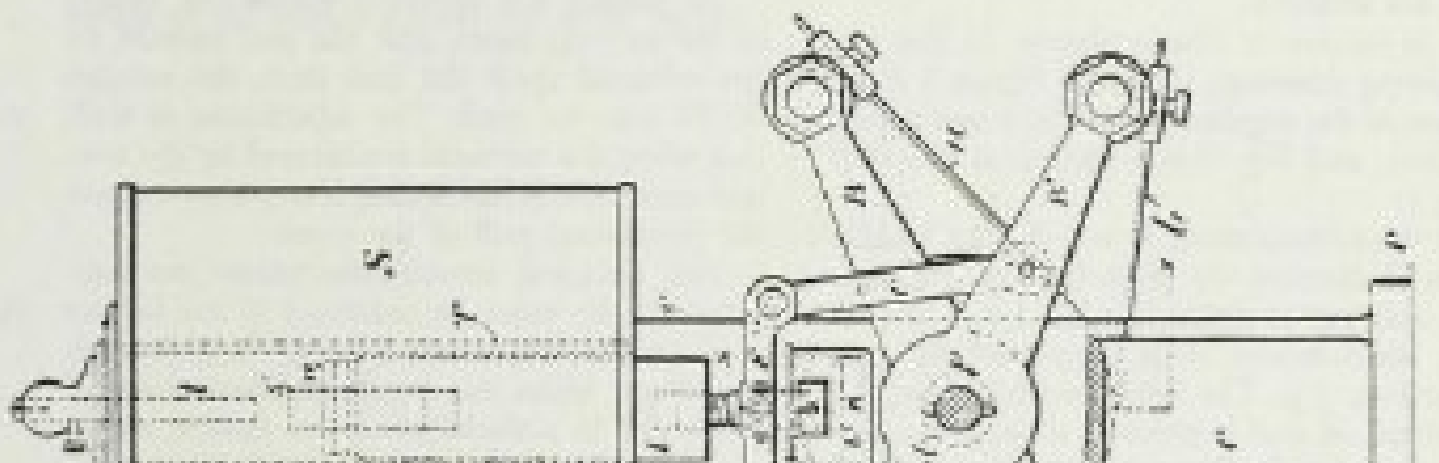
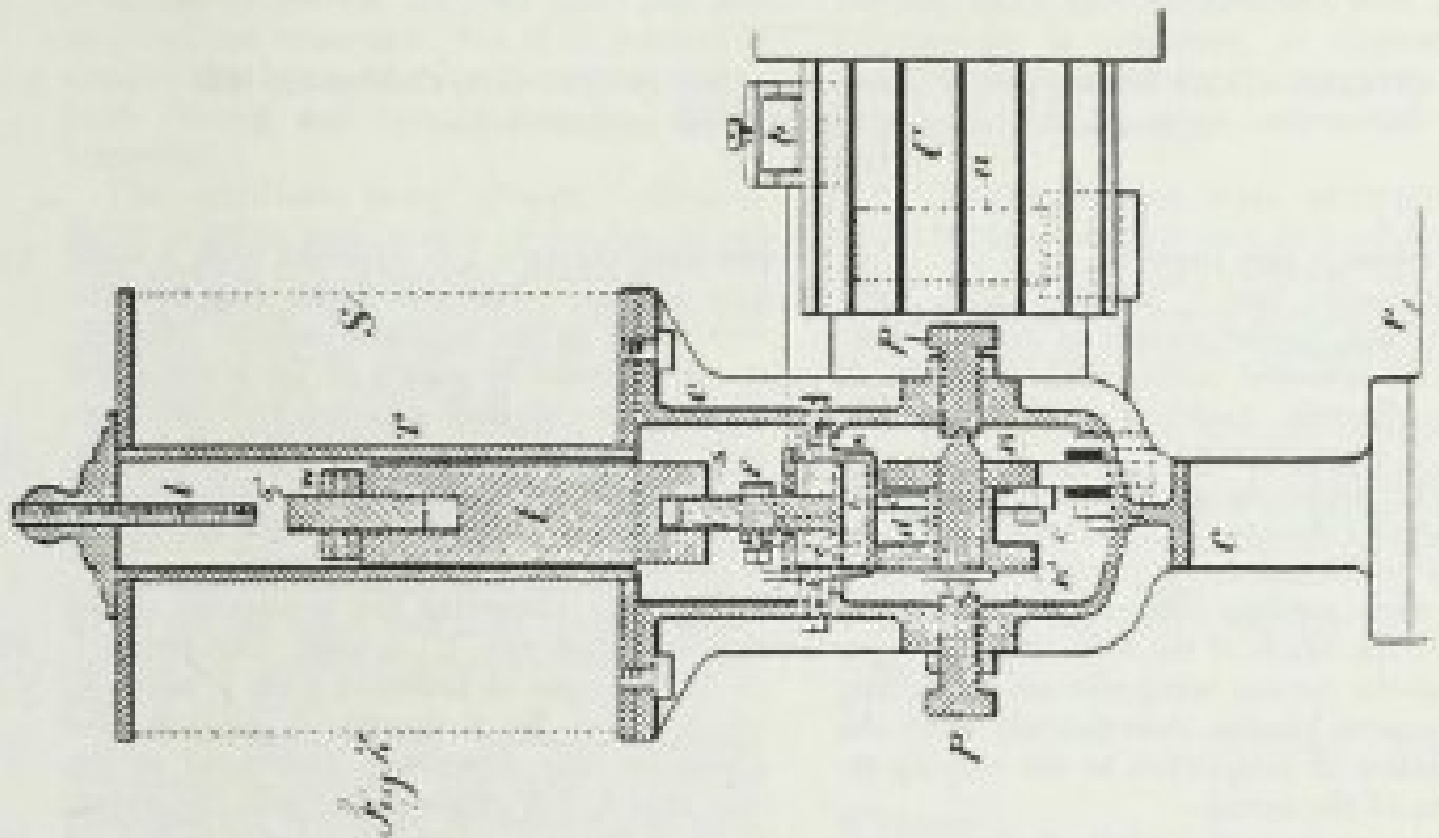
THE COMPLETE PATENTS OF NIKOLA TESLA

N. TESLA.

REGULATOR FOR DYNAMO ELECTRIC MACHINES.

No. 350,954.

Patented Oct. 19, 1886.



THE COMPLETE PATENTS OF NIKOLA TESLA

THE TESLA ELECTRIC LIGHT AND MANUFACTURING COMPANY, OF
RAHWAY, NEW JERSEY

COMMUTATOR FOR DYNAMO-ELECTRIC MACHINES.

SPECIFICATION forming part of Letters Patent No. 334,823, dated January 26, 1886.
Application filed May 6, 1885. Serial No. 164,534. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, of Smiljan Lika, border country of Austria-Hungary, have invented an Improvement in Dynamo-Electric Machines, of which the following is a specification.

My invention relates to the commutators on dynamo-electric machines, especially in machines of great electromotive force, adapted to arc lights; and it consists in a device by means of which the sparking on the commutator is prevented.

It is known that in machines of great electromotive force—such, for instance, as those used for arc lights—whenever one commutator bar or plate comes out of contact with the collecting-brush a spark appears on the commutator. This spark may be due to the break of the complete circuit, or of a shunt of low resistance formed by the brush between two or more commutator-bars. In the first case the spark is more apparent, as there is at the moment when the circuit is broken a discharge of the magnets through the field-helices, producing a great spark or flash which causes an unsteady current, rapid wear of the commutator bars and brushes, and waste of power. The sparking may be reduced by various devices, such as providing a path for the current at the moment when the commutator segment or bar leaves the brush, by short-circuiting the field-helices, by increasing the number of the commutator-bars, or by other similar means; but all these devices are expensive or not fully available, and seldom attain the object desired.

My invention enables me to prevent the sparking in a simple manner. For this purpose

intervening insulating material; B B, the brushes, *a a* are sheets of asbestos paper or other suitable non-conducting material. *ff* are springs, the pressure of which may be adjusted by means of the screws *g g*.

In Fig. 2 a sample arrangement is shown with two plates of mica or other material. It will be seen that whenever one commutator-segment passes out of contact with the brush the formation of the arc will be prevented by the intervening insulating material coming in contact with the insulating material on the brush.

My invention may be carried out in many ways; and I do not limit myself to any particular device, as my invention consists, broadly, in providing a solid non-conducting body to bear upon the surface of the commutator, by the intervention of which body the sparking is partly or completely prevented.

I prefer to use asbestos paper or cloth impregnated with zinc-oxide, magnesia, zirconia, or other suitable material, as the paper and cloth are soft, and serve at the same time to wipe and polish the commutator; but mica or any other suitable material may be employed, said material being an insulator or a bad conductor of electricity.

My invention may be applied to any electric apparatus in which sliding contacts are employed.

I claim as my invention—

1. The combination, with the commutator-bars and intervening insulating material and brushes in a dynamo electric machine, of a solid insulator or bad conductor of electricity arranged to bear upon the surface of the commutator adjacent to the end of the brush, for the purpose set forth.

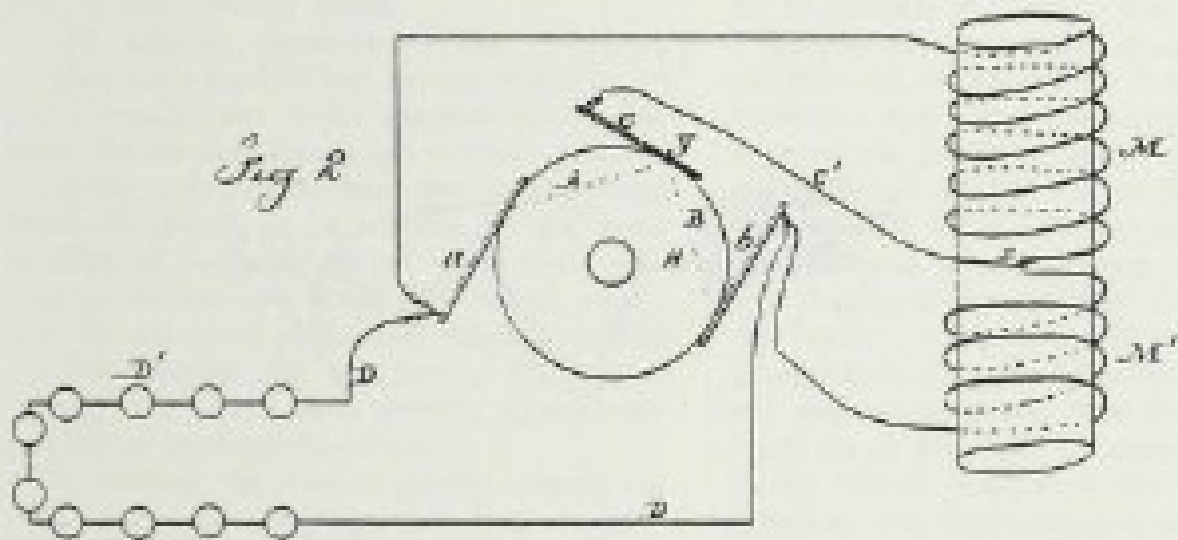
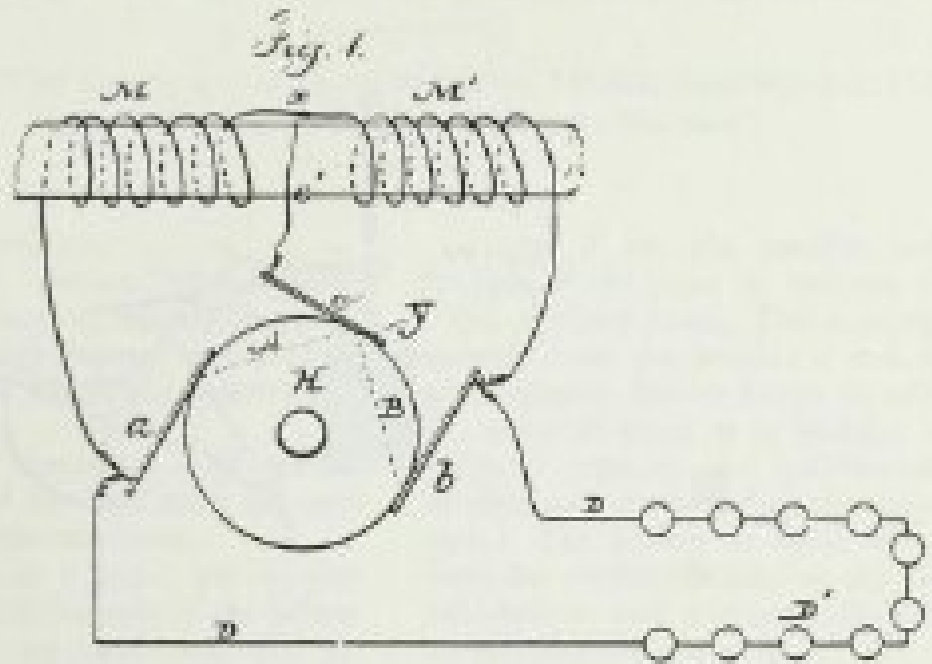
THE COMPLETE PATENTS OF NIKOLA TESLA

N. TESLA.

REGULATOR FOR DYNAMO ELECTRIC MACHINES.

No. 336,961.

Patented Mar. 2, 1886.



THE COMPLETE PATENTS OF NIKOLA TESLA

NIKOLA TESLA, OF NEW YORK, N. Y.

ELECTRIC GENERATOR.

SPECIFICATION forming part of Letters Patent No. 511,916, dated January 2, 1894.
Application filed August 19, 1893. Serial No. 483,562. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electric Generators, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

In an application of even date herewith, Serial No. 483,563, I have shown and described a form of engine invented by me, which, under the influence of an applied force such as the elastic tension of steam or a gas under pressure, yields an oscillation of constant period.

In order that my present invention may be more readily understood I will explain the conditions which are to be observed in order to secure this result.

It is a well known mechanical principle that if a spring possessing a sensible inertia be brought under tension, as by being stretched, and then freed, it will perform vibrations which are isochronous, and as to period, in the main, dependent upon the rigidity of the spring, and its own inertia or that of the system of which it may form an immediate part. This is known to be true in all cases where the force which tends to bring the spring or movable system into a given position is proportionate to the displacement.

In the construction of my engine above referred to I have followed and applied this principle, that is to say, I employ a cylinder and a piston which in any suitable manner I maintain in reciprocation by steam or gas under pressure. To the moving piston or to the cylinder, in case the latter reciprocate and the piston remain stationary, a spring is connected so as to be maintained in vibration thereby, and whatever may be the inertia of the piston or of the moving system and the rigidity of the spring relatively to each other, provided, the practical limits within which the law holds true that the forces which tend to bring the moving system to a given position are proportionate to the displacement, are not exceeded,

the natural vibrations of the spring will always correspond in direction and coincide in time. In the case of the engine referred to, the ports are so arranged that the movement of the piston within the cylinder in either direction ceases when the force tending to impel it and the momentum which it has acquired are counterbalanced by the increasing pressure of the steam or compressed air in that end of the cylinder toward which it is moving, and as in its movement the piston has shut off at a given point, the pressure that impelled it and established the pressure that tends to return it, it is then impelled in the opposite direction, and this action is continued as long as the requisite pressure is applied. The length of the stroke will vary with the pressure, but the rate or period of reciprocation is no more dependent upon the pressure applied to drive the piston, than would be the period of oscillation of a pendulum permanently maintained in vibration, upon the force which periodically impels it, the effect of variations in such force being merely to produce corresponding variations in the length of stroke or amplitude of vibration respectively.

In practice I have found that the best results are secured by the employment of an air spring, that is, a body of confined air or gas which is compressed and rarefied by the movements of the piston, and in order to secure a spring of constant rigidity I prefer to employ a separate chamber or cylinder containing air at the normal atmospheric pressure, although it might be at any other pressure, and in which works a plunger connected with or carried by the piston rod. The main reason why no engine heretofore has been capable of producing results of this nature is that it has been customary to connect with the reciprocating parts a heavy fly-wheel or some equivalent rotary system of relatively very great inertia, or in other cases where no rotary system was employed, as in certain reciprocating engines or tools, no regard has been paid to the obtaining of the conditions essential to the end which I have in view, nor would the pressure of such conditions, in said devices, approach

the movements of the piston to a core or coil in a magnetic field. It should be stated however, that in applying the engine for this purpose certain conditions are encountered which should be taken into consideration in order to satisfactorily secure the desired result. When a conductor is moved in a magnetic field and a current caused to circulate therein, the electro-magnetic reaction between it and the field, might disturb the mechanical oscillation to such an extent as to throw it out of isochronism. This, for instance, might occur when the electro-magnetic reaction is very great in comparison to the power of the engine, and there is a retardation of the current so that the electro-magnetic reaction might have an effect similar to that which would result from a variation of the tension of the spring, but if the circuit of the generator be so adjusted that the phases of the electromotive force and current coincide in time, that is to say, when the current is not retarded, then the generator driven by the engine acts merely as a frictional resistance and will not, as a rule, alter the period of the mechanical vibration, although it may vary its amplitude. This condition may be readily secured by properly proportioning the self induction and capacity of the circuit including the generator. I have, however, observed the further fact in connection with the use of such engines as a means for running a generator, that it is advantageous that the period of the engine and the natural period of electrical vibration of the generator should be the same, as in such case the best conditions for electrical resonance are established and the possibility of disturbing the period of mechanical vibrations is reduced to a minimum. I have found that even if the theoretical conditions necessary for maintaining a constant period in the engine itself are not exactly maintained, still the engine and generator combined will vibrate at a constant period. For example, if instead of using in the engine an independent cylinder and plunger, as an air spring of practically constant rigidity, I cause the piston to impinge upon air cushions at the ends of its own cylinder, although the rigidity of such cushions or springs might be considerably affected and varied by the variations of pressure within the cylinder, still by combining with such an engine a generator which has a period of its own approximately that of the engine, constant vibration may be maintained even through a considerable range of varying pressure, owing to the controlling action of the electro-magnetic system. I have even found that under certain conditions the influence of the electro-magnetic system may be made so great as to entirely control the

change its rate. So, for the sake of illustration, if a pendulum is started in vibration, and a small force applied periodically in the proper direction to maintain it in motion, this force would have no substantial control over the period of the oscillation, unless the inertia of the pendulum be small in comparison to the impelling force, and this would be true no matter through what fraction of the period the force may be applied. In the case under consideration the engine is merely an agent for maintaining the vibration once started, although it will be understood that this does not preclude the performance of useful work which would simply result in a shortening of the stroke. My invention, therefore, involves the combination of a piston free to reciprocate under the influence of steam or a gas under pressure and the movable element of an electric generator which is in direct mechanical connection with the piston, and it is more especially the object of my invention to secure from such combination electric currents of a constant period. In the attainment of this object I have found it preferable to construct the engine so that it of itself controls the period, but as I have stated before, I may so modify the elements of the combination that the electro-magnetic system may exert a partial or even complete control of the period.

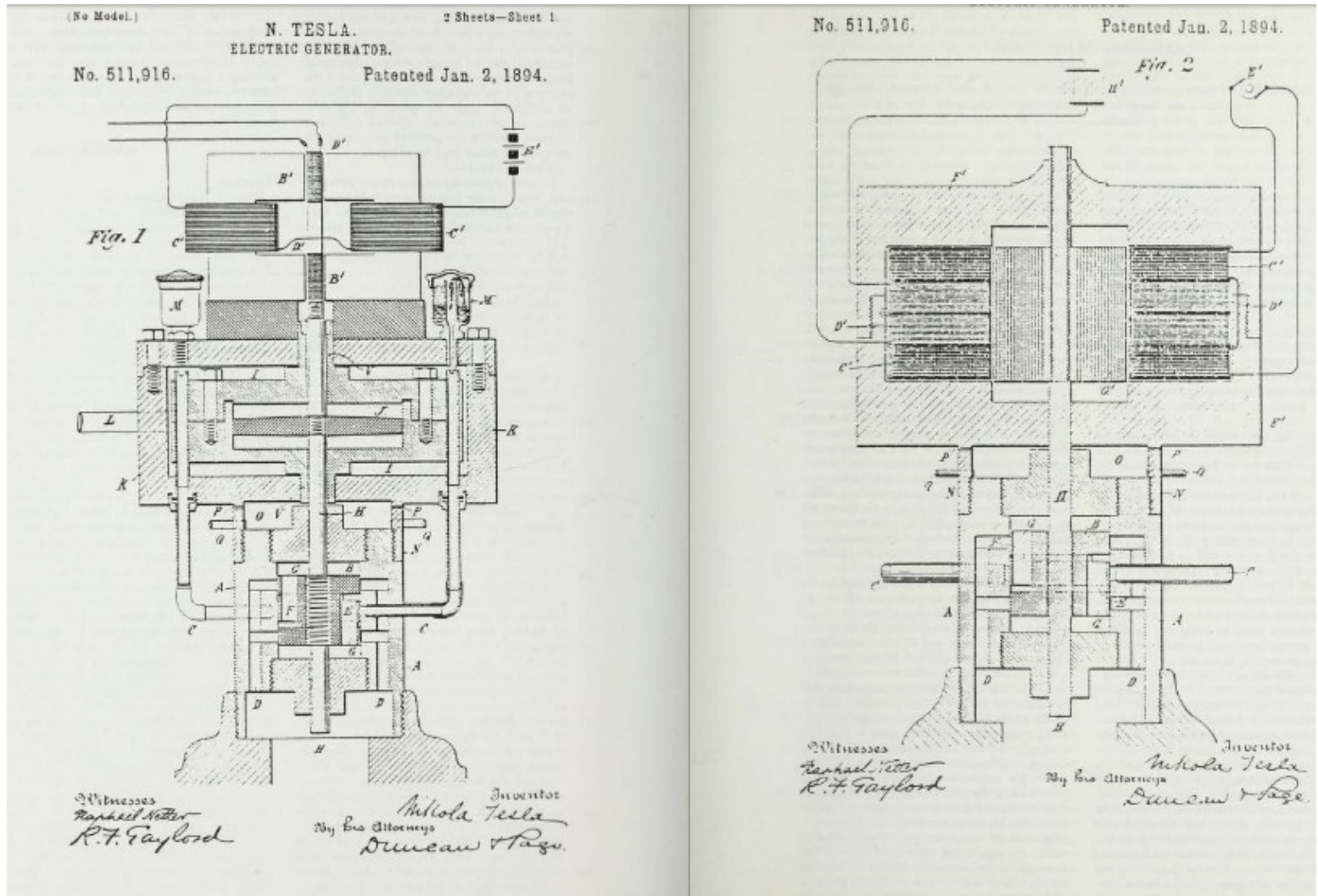
In illustration of the manner in which the invention is carried out I now refer to the accompanying drawings.

Figure 1 is a central sectional view of an engine and generator embodying the invention. Fig. 2 is a modification of the same.

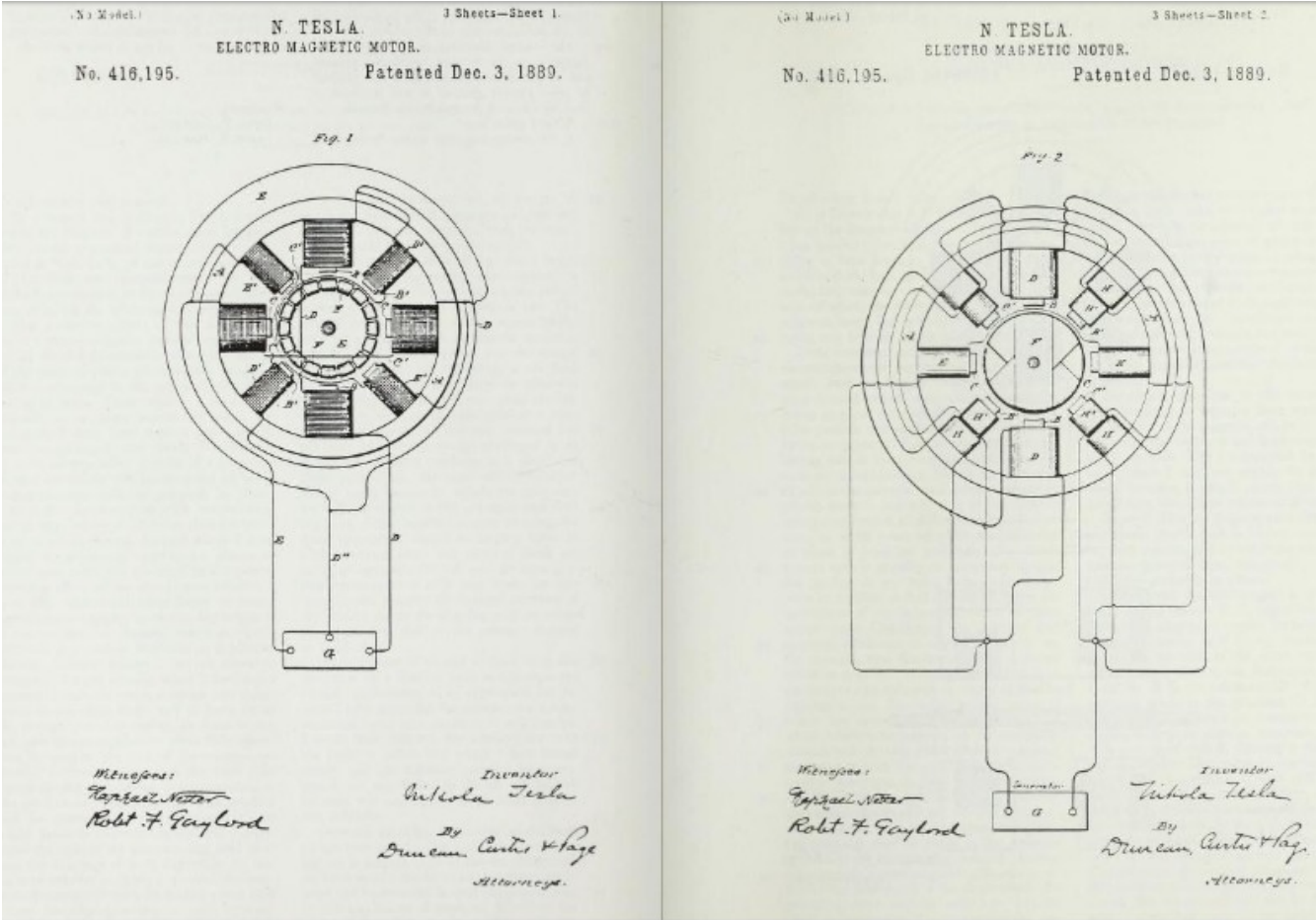
Referring to Fig. 1 A is the main cylinder in which works a piston B. Inlet ports C C pass through the sides of the cylinder opening at the middle portion thereof and on opposite sides. Exhaust ports D D extend through the walls of the cylinder and are formed with branches that open into the interior of the cylinder on each side of the inlet ports and on opposite sides of the cylinder. The piston B is formed with two circumferential grooves E F which communicate through openings G in the piston with the cylinder on opposite sides of said piston respectively.

The particular construction of the cylinder, the piston and the ports controlling it may be very much varied, and is not in itself material, except that in the special case now under consideration it is desirable that all the ports, and more especially the exhaust ports should be made very much larger than is usually the case so that no force due to the action of the steam or compressed air will tend to retard or affect the return of the piston in either direction. The piston B is secured to a piston rod H

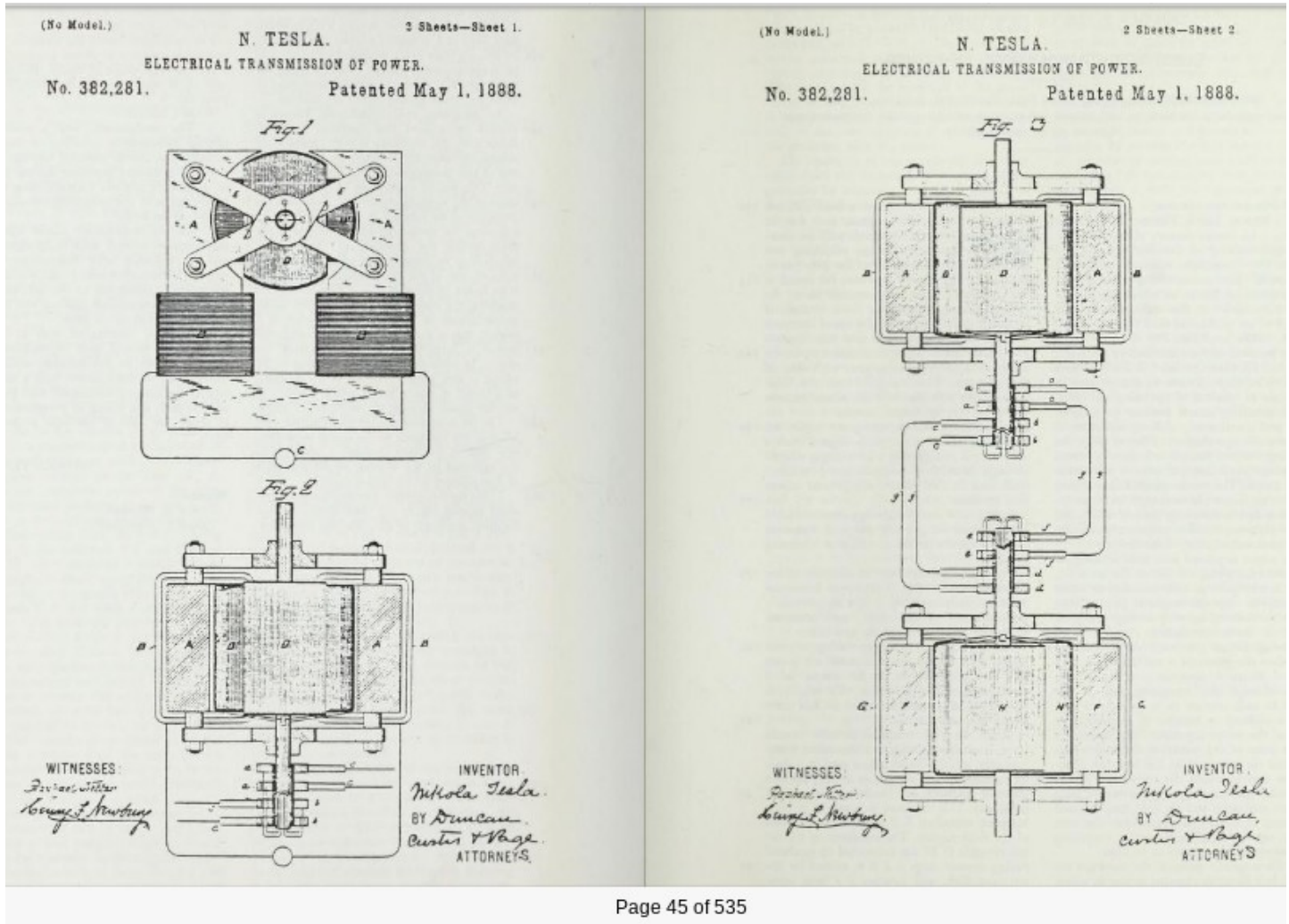
THE COMPLETE PATENTS OF NIKOLA TESLA



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THE COMPLETE PATENTS OF NIKOLA TESLA

(No Model.)

2 Sheets—Sheet 2.

N. TESLA.

ELECTRO MAGNETIC MOTOR.

No. 382,279.

Patented May 1, 1888.

Fig. 3.

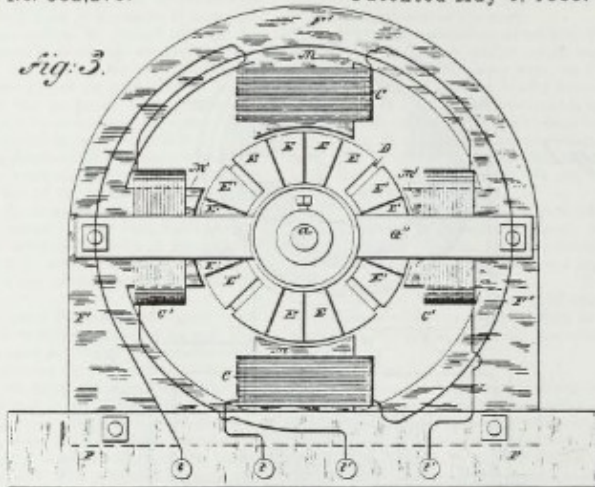
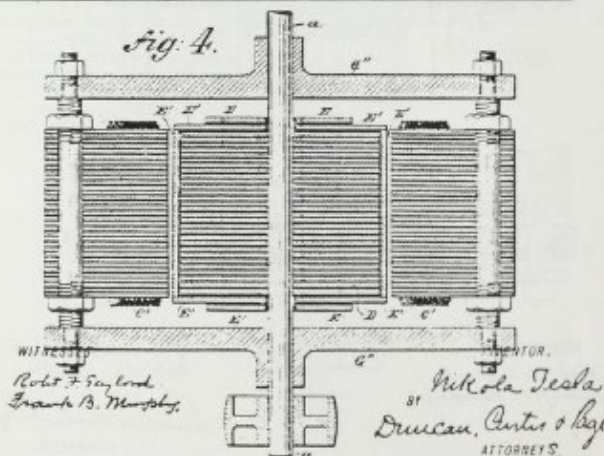


Fig. 4.



CHARLES F. PECK, OF ENGLEWOOD, NEW JERSEY.

ELECTRO-MAGNETIC MOTOR.

SPECIFICATION forming part of Letters Patent No. 382,279, dated May 1, 1888.

Application filed November 30, 1887. Serial No. 256,561. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria, from Smiljan, Lika, border country of Austria-Hungary, now residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electro-Magnetic Motors, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

In a former application, filed October 12, 1887, No. 252,132, I have shown and described a mode or plan of operating electric motors by causing a progressive shifting of the poles of one or both of the parts or elements of a motor—that is to say, of either the field magnet or magnets or armature, or both. I accomplish this by constructing a motor with two or more independent energizing-circuits, on the field-magnets, for example, and I connect these up with corresponding induced or generating circuits in an alternating-current generator, so that alternating currents are caused to traverse the motor-circuits. By so doing the poles of the field-magnet of the motor are progressively shifted, and by their attraction upon a rotary armature set up a rotation in the latter in the direction of the movement of the poles. In this case, however, the rotation is produced and maintained by the direct attraction of the magnetic elements of the motor. I have discovered that advantageous results may be secured in this system by utilizing the shifting of the poles primarily to set up currents in a closed conductor located within the influence of the field of the motor, so that the rotation may result from the reaction of such currents upon the field.

To illustrate more fully the nature of the invention I refer to the accompanying drawings.

Figure 1 represents in side elevation the operative parts or elements of a motor embodying the principles of my invention, and in section the generator for operating the same.

Fig. 2 is a horizontal central section of the motor in Fig. 1, the circuits being shown partly in diagram. Fig. 3 is a modified form of motor in side elevation. Fig. 4 is a central

In Figs. 1 and 2, A is an annular core of soft iron, preferably laminated or formed of insulated sections, so as to be susceptible to rapid variations of magnetism. This core is wound with four coils, C C C' C', the diametrically-opposite coils being connected in the same circuit, and the two free ends of each pair being brought to the terminals *t* and *t'*, respectively, as shown. Within this annular field-magnet A is mounted a soft-iron cylinder or disk, D, on an axis, *a*, in bearings *b* *b*, properly supported by the frame-work of the machine. The disk carries two coils, E E', of insulated wire, wound at right angles to one another, and having their respective ends joined, so that each coil forms a separate closed circuit.

In illustration of the action or mode of operation of this apparatus, let it be assumed that the annular field-magnet A is permanently magnetized, so as to present two free poles diametrically opposite. If suitable mechanical provision be now made for rotating the field-magnet around the disk, the apparatus exemplifies the conditions of an ordinary magneto-generator, and currents would be set up in the coils or closed conductors E E' on the disk D. Evidently these currents would be the most powerful at or near the points of the greatest density of the lines of force, and they would, as in all similar cases, tend, at least theoretically, to establish magnetic poles in the disk D at right angles to those in the annular field-magnet A. As a result of the well-known reaction of these polarities upon each other, more or less powerful tendency in the disk to rotate in the same direction as that of the field-magnet would be established. If, on the other hand, the ring or annular field-magnet A be held stationary and its magnetic poles progressively shifted by passing through its coils C C' properly-alternated currents, it is obvious that similar results will follow, for the passage of the currents causing the shifting or whirling of the poles of the field-magnet A induces currents in the closed circuits of the armature coils E E', with the result of setting up a rotation of the disk D in the same direc-

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The operation of this system will be understood from the foregoing. The action of the generator, by causing a progressive shifting of the poles in the motor-armature, sets up in the latter a rotation opposite in direction to that in which the poles move. If, now, the continuous current be directed through the field coils, so as to strongly energize the magnet A A, the speed of the motor, which depends upon that of the generator, will not be increased, but the power which produces its rotation will be increased in proportion to the energy supplied through the coils B B.

It is characteristic of this motor that its direction of rotation is not reversed by reversing the direction of the current through its field-coils, for the direction of rotation depends not upon the polarity of the field, but upon the direction in which the poles of the armature are shifted. To reverse the motor, the connections of either of the circuits g g' must be reversed.

I have found that if the field-magnet of the motor be strongly energized by its coils B B and the circuits through the armature-coils closed, assuming the generator to be running at a certain speed, the motor will not start; but if the field be but slightly energized or in general in such condition that the magnetic influence of the armature preponderates in determining its magnetic condition the motor will start and, with sufficient current, will reach its maximum or normal speed. For this reason it is desirable to keep at the start and until the motor has attained its normal speed, or nearly so, the field-circuit open or to permit but little current to pass through it. I have found, however, if the fields of both the generator and motor be strongly energized that starting the generator starts the motor, and

loads within their normal working limits; and in practice I have observed that if the motor be overloaded to such an extent as to check its speed the speed of the generator, if its motive power be not too great, is diminished synchronously with that of the motor.

I have in other applications shown how the construction of these or similar motors may be varied in certain well-known ways—as, for instance, by rotating the field about a stationary armature or rotating conductors within the field; but I do not illustrate these features further herein, as with the illustration which I have given I regard the rest as within the power of a person skilled in the art to construct.

The present form of motor is cheap, simple, reliable, and easy to maintain. It requires the simplest type of generator for its operation, and when properly constructed shows a high efficiency.

I do not claim herein the method of transmitting power which this system involves, having made it the subject of another application for patent.

What I claim is—

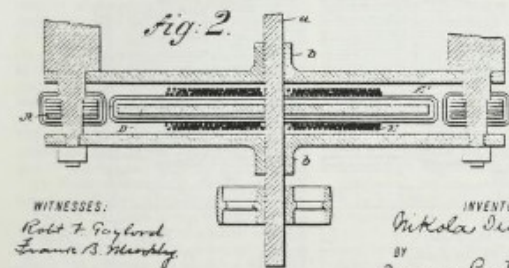
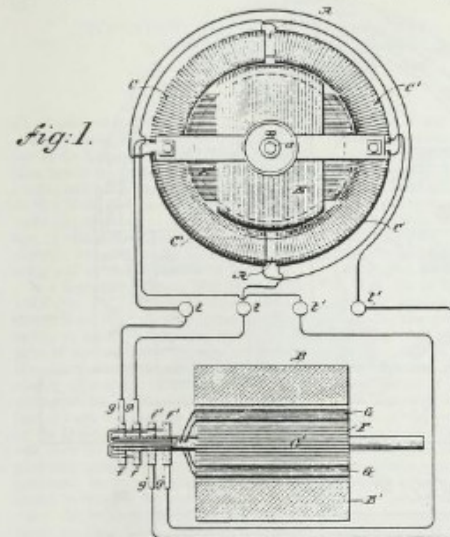
The combination, with a motor having independent energizing or armature circuits, of an alternating-current generator with corresponding induced circuits connected with the motor for effecting a progressive shifting of the poles of the motor armature, and a source of continuous current for energizing the field of said motor, as set forth.

NIKOLA TESLA.

Witnesses:

FRANK B. MURPHY,
FRANK E. HARTLEY.

N. TESLA.
ELECTRO MAGNETIC MOTOR.
No. 382,279. Patented May 1, 1888.



WITNESSES:
Rolt F. Gaylord
Francis B. Mordley

INVENTOR
Nikola Tesla
BY
Duncan Curtis & Co.
ATTORNEYS.

THE COMPLETE PATENTS OF NIKOLA TESLA

ELECTRO-MAGNETIC MOTOR.

No. 381,969. Patented May 1, 1888.

Fig. 3

WITNESSES:
Robert P. Gray, Secy.
Frank A. Murphy.

INVENTOR:
Nikola Tesla

ATTORNEY:
Driscoll, Carter & May

CHARLES F. PECK, OF ENGLEWOOD, NEW JERSEY.

ELECTRO-MAGNETIC MOTOR.

SPECIFICATION forming part of Letters Patent No. 381,969, dated May 1, 1888.
Application filed November 30, 1887. Serial No. 256,502. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, from Smiljan Lika, border county of Austria-Hungary, now residing in New York, in the county and State of New York, have invented certain new and useful Improvements in Electro-Magnetic Motors, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

In an application filed by me October 12, 1887, No. 252,132, I have shown and described a novel form of electro-magnetic motor and a mode of operating the same, which may be generally described as follows: The motor is wound with coils forming independent energizing circuits on either the armature or field magnet, or both, (it is sufficient for present purposes to consider the case in which the coils are on the armature alone,) and these coils are connected up with corresponding circuits on an alternating current generator. As the result of this, currents of alternately-opposite direction are sent through the energizing-coils of the motor in such manner as to produce a progressive shifting or rotation of the magnetic poles of the armature. This movement of the poles of the armature obviously tends to rotate the armature in the opposite direction to that in which the movement of the poles takes place, owing to the attractive force between said poles and the field-magnets, and the speed of rotation increases from the start until it equals that of the generator, supposing both motor and generator to be alike.

As the poles of the armature are shifted in a direction opposite to that in which the armature rotates, it will be apparent that when the normal speed is attained the poles of the armature will assume a fixed position relative to the field-magnet, and that in consequence the field-magnets will be energized by magnetic induction, exhibiting two distinct poles, one in each of the pole-pieces. In starting the motor, however, the speed of the armature being comparatively slow, the pole-pieces are subjected to rapid reversals of magnetic polarity; but as the speed increases these reversals

when the movement of the armature become synchronous with that of the generator. This being the case, the field-cores and the pole-pieces of the motor become a magnet, but by induction only.

I have found that advantageous results are secured by winding the field-magnets with a coil or coils and passing a continuous current through them, thus maintaining a permanent field, and in this feature my present invention consists.

I shall now describe the apparatus which I have devised for carrying out this invention and explain the mode of using or operating the same.

Figure 1 is an end view in elevation of my improved motor. Fig. 2 is a part horizontal central section, and Fig. 3 is a diagrammatic representation of the motor and generator combined and connected for operation.

Let A A in Fig. 1 represent the legs or pole-pieces of a field-magnet, around which are coils B B, included in the circuit of a continuous-current generator, C, which is adapted to impart magnetism to the said poles in the ordinary manner.

D D' are two independent coils wound upon a suitable cylindrical or equivalent armature-core, which, like all others used in a similar manner, should be split or divided up into alternate magnetic and insulating parts in the usual way. This armature is mounted in non-magnetic cross-bars E E, secured to the poles of the field-magnet. The terminals of the armature-coils D D' are connected to insulated sliding contact-rings a a b b, carried by the armature shaft, and brushes c c' bear upon these rings to convey to the coils the currents which operate the motor.

The generator for operating this motor is or may be of precisely identical construction; and for convenience of reference I have marked in Fig. 3 its parts, as follows: F F, the field-magnets, energized by a continuous current passing in its field-coils G G; H H', the coils carried by the cylindrical armature; d d e e, the friction or collecting rings, carried by the armature-shaft and forming the termi-

THE COMPLETE PATENTS OF NIKOLA TESLA

and not intermittent. In addition to this, the practical difficulty of interrupting or reversing a current of any considerable strength is such
495 that none of the devices at present could be made to economically or practically effect the transmission of power by reversing in the manner described a continuous or direct current. In so far, then, as the plan of acting
500 upon one element of the motor is concerned, my invention involves the use of an alternating as distinguished from a reversed current, or a current which, while continuous and direct, is shifted from coil to coil by any form of
505 commutator, reverser, or interrupter. With regard to that part of the invention which consists in acting upon both elements of the motor simultaneously, I regard the use of ci-

practical importance.

What I claim is—

The method herein described of electrically transmitting power, which consists in producing a continuously progressive shifting of the polarities of either or both elements (the armature or field magnet or magnets) of a motor by developing alternating currents in independent circuits, including the magnetizing-coils of either or both elements, as herein set forth.

NIKOLA TESLA.

Witnesses:

FRANK B. MURPHY,

FRANK E. HARTLEY.

N. TESLA.
ELECTRO MAGNETIC MOTOR.
No. 381,969. Patented May 1, 1888.

Fig. 1.

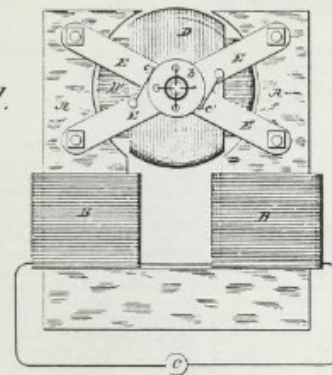
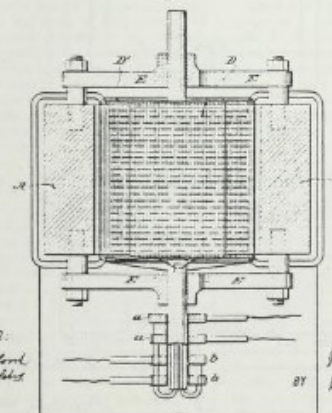


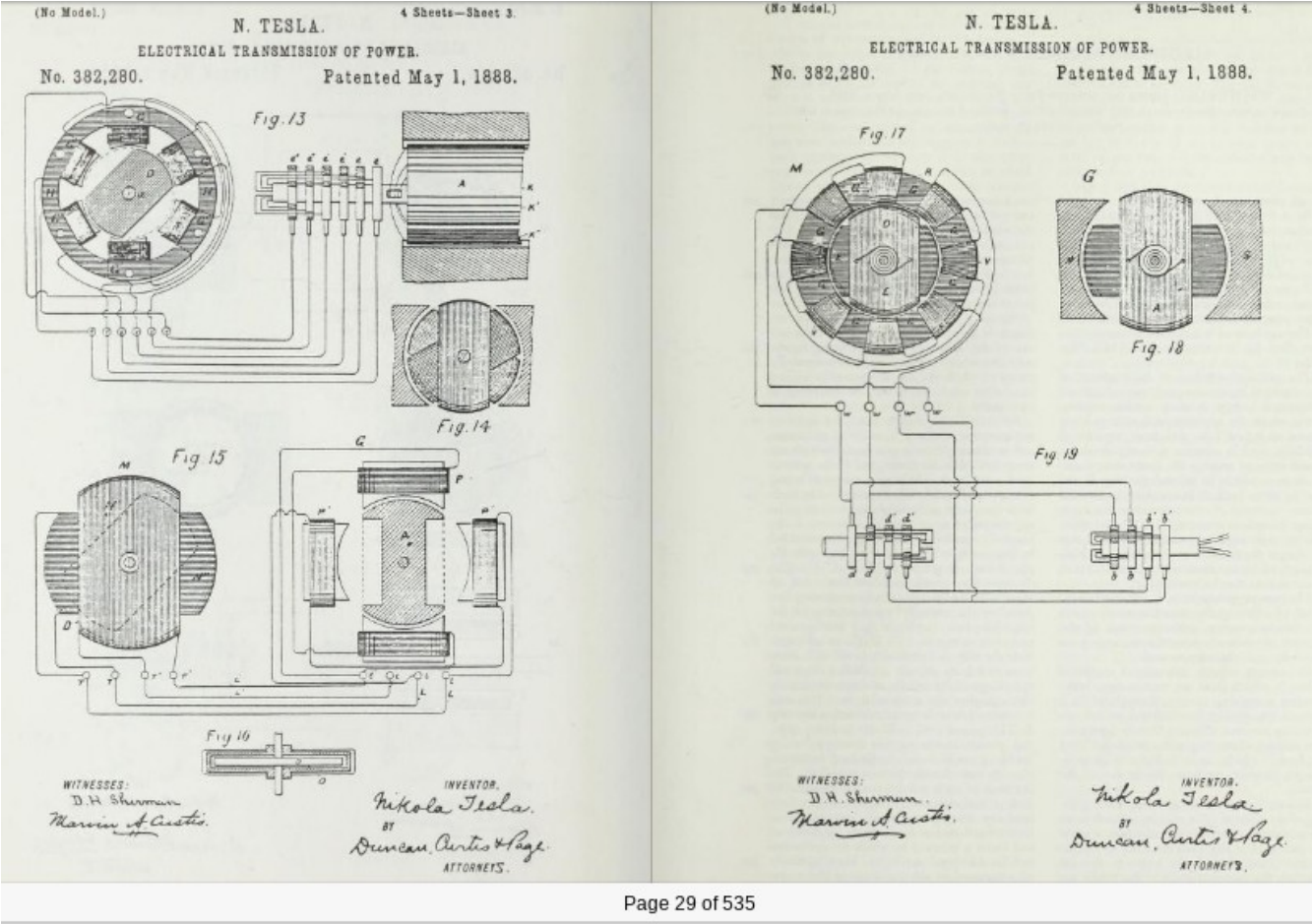
Fig. 2.



WITNESSES:
Robt F. Taylor
James B. Marshall

INVENTOR:
Nikola Tesla.
Duncan Curtis.
V. Page

THE COMPLETE PATENTS OF NIKOLA TESLA



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THE COMPLETE PATENTS OF NIKOLA TESLA

(No Model)

N. TESLA.

4 Sheets—Sheet 4.

ELECTRO MAGNETIC MOTOR.

No. 381,968.

Patented May 1, 1888.

Fig. 17.

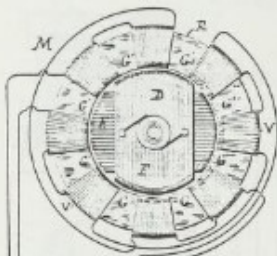


Fig. 18.

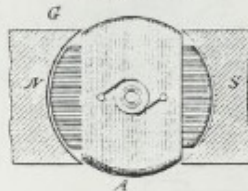
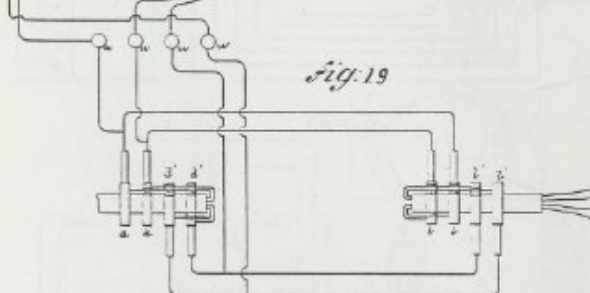


Fig. 19.



WITNESSES:

Francis E. Huntley
James B. Murphy.

INVENTOR:

Nikola Tesla,
BY
Duncan, Curtis & Page
ATTORNEYS.

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR OF ONE-HALF TO
CHARLES F. PECK, OF ENGLEWOOD, NEW JERSEY.

ELECTRO-MAGNETIC MOTOR.

SPECIFICATION forming part of Letters Patent No. 381,968, dated May 1, 1888.
Application filed October 12, 1887. Serial No. 292,132. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, from Smiljan Lika, border country of Austria-Hungary, residing at New York, N. Y., have invented certain new and useful Improvements in Electro-Magnetic Motors, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

The practical solution of the problem of the electrical conversion and transmission of mechanical energy involves certain requirements which the apparatus and systems heretofore employed have not been capable of fulfilling. Such a solution, primarily, demands a uniformity of speed in the motor irrespective of its load within its normal working limits. On the other hand, it is necessary, to attain a greater economy of conversion than has heretofore existed, to construct cheaper and more reliable and simple apparatus, and, lastly, the apparatus must be capable of easy management, and such that all danger from the use of currents of high tension, which are necessary to an economical transmission, may be avoided.

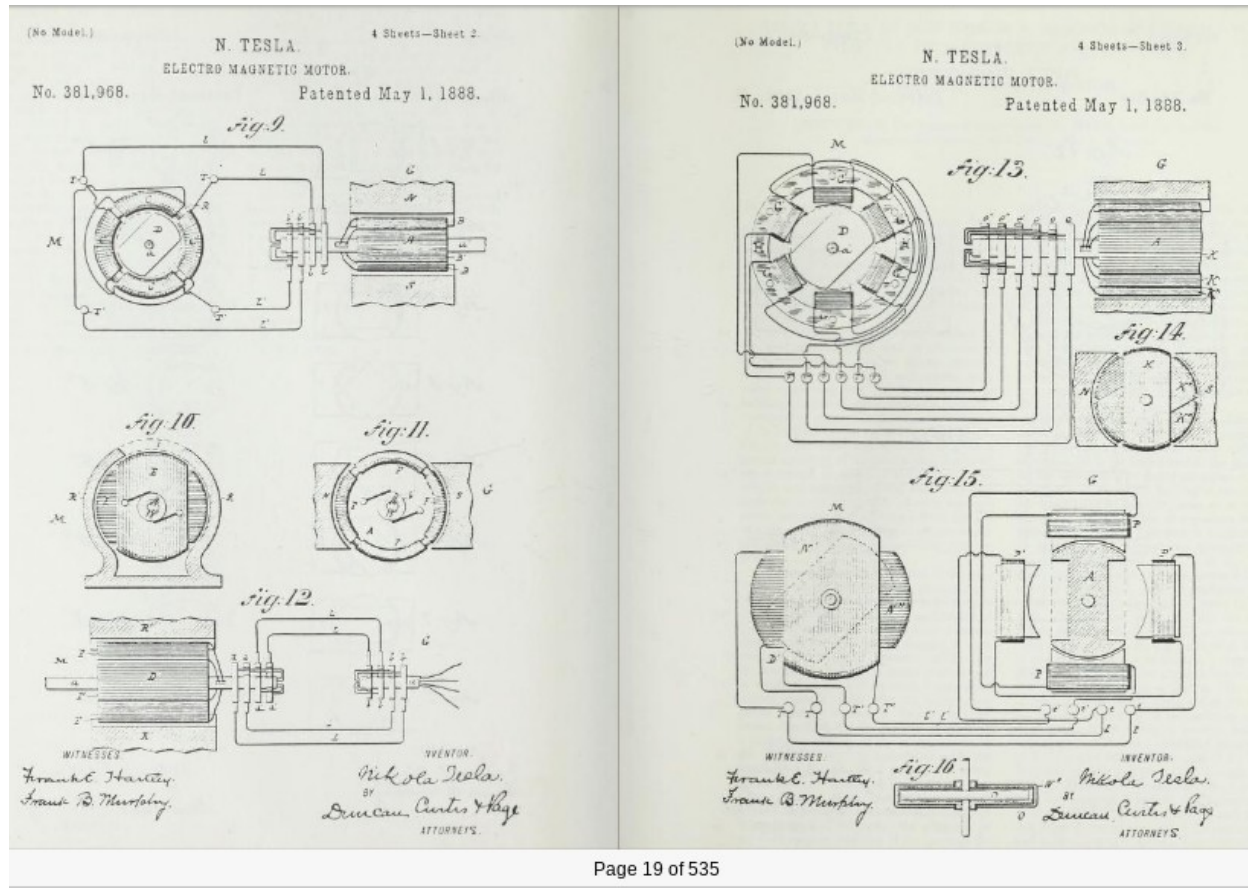
My present invention is directed to the production and improvement of apparatus capable of more nearly meeting these requirements than those heretofore available, and though I have described various means for the purpose, they involve the same main principles of construction and mode of operation, which may be described as follows: A motor is employed in which there are two or more independent circuits through which alternate currents are passed at proper intervals, in the manner hereinafter described, for the purpose of effecting a progressive shifting of the magnetism or of the "lines of force" in accordance with the well-known theory, and a consequent action of the motor. It is obvious that a proper progressive shifting of the lines of force may be utilized to set up a movement or rotation of either element of the motor, the armature, or the field magnet, and that if the currents di-

avoid all the usual commutating appliances in the system I prefer to connect the motor-circuits directly with those of a suitable alternate-current generator. The practical results of such a system, its economical advantages, and the mode of its construction and operation will be described more in detail by reference to the accompanying diagrams and drawings.

Figures 1 to 8 and 1' to 8', inclusive, are diagrams illustrating the principle of the action of my invention. The remaining figures are views of the apparatus in various forms by means of which the invention may be carried into effect, and which will be described in their order.

Referring first to Fig. 9, which is a diagrammatic representation of a motor, a generator, and connecting-circuits in accordance with my invention, M is the motor, and G the generator for driving it. The motor comprises a ring or annulus, R, preferably built up of thin insulated iron rings or annular plates, so as to be as susceptible as possible to variations in its magnetic condition. This ring is surrounded by four coils of insulated wire symmetrically placed, and designated by C C' C' C'. The diametrically-opposite coils are connected up so as to co-operate in pairs in producing free poles on diametrically-opposite parts of the ring. The four free ends thus left are connected to terminals T T' T' T', as indicated. Near the ring, and preferably inside of it, there is mounted on an axis or shaft, a, a magnetic disk, D, generally circular in shape, but having two segments cut away, as shown. This disk is mounted so as to turn freely within the ring R. The generator G is of any ordinary type, that shown in the present instance having field-magnets N S and a cylindrical armature-core, A, wound with the two coils B B'. The free ends of each coil are carried through the shaft a' and connected, respectively, to insulated contact-rings b b' b' b'. Any convenient form of collector or brush bears on each ring and forms a terminal by which the current to and from a ring is conveyed. These terminals

THE COMPLETE PATENTS OF NIKOLA TESLA



(No Model.)

3 Sheets—Sheet 2

N. TESLA.
DYNAMO ELECTRIC MACHINE.

No. 359,748.

Patented Mar. 22, 1887.

Fig. 4 is a plan view of a component with a central rectangular opening and a smaller central circle, surrounded by a series of small rectangular protrusions. Fig. 5 is a cross-sectional view of a component with a central circular opening and a series of small rectangular protrusions. Fig. 6 is a cross-sectional view of a component with a central circular opening and a series of small rectangular protrusions.

Witness
Charles H. Smith,
J. Stark.

Inventor
Nikola Tesla
By W. B. Smith

(No Model.)

3 Sheets—Sheet 3

N. TESLA.
DYNAMO ELECTRIC MACHINE.

No. 359,748.

Patented Mar. 22, 1887.

Fig. 7 is a circular diagram showing a radial arrangement of components. It consists of a central circle with a series of radial lines extending from it to a larger outer circle. Each radial line has a small rectangular component at its end, and these components are arranged in a circular pattern around the center.

Witness

Charles H. Smith,
J. Stark.

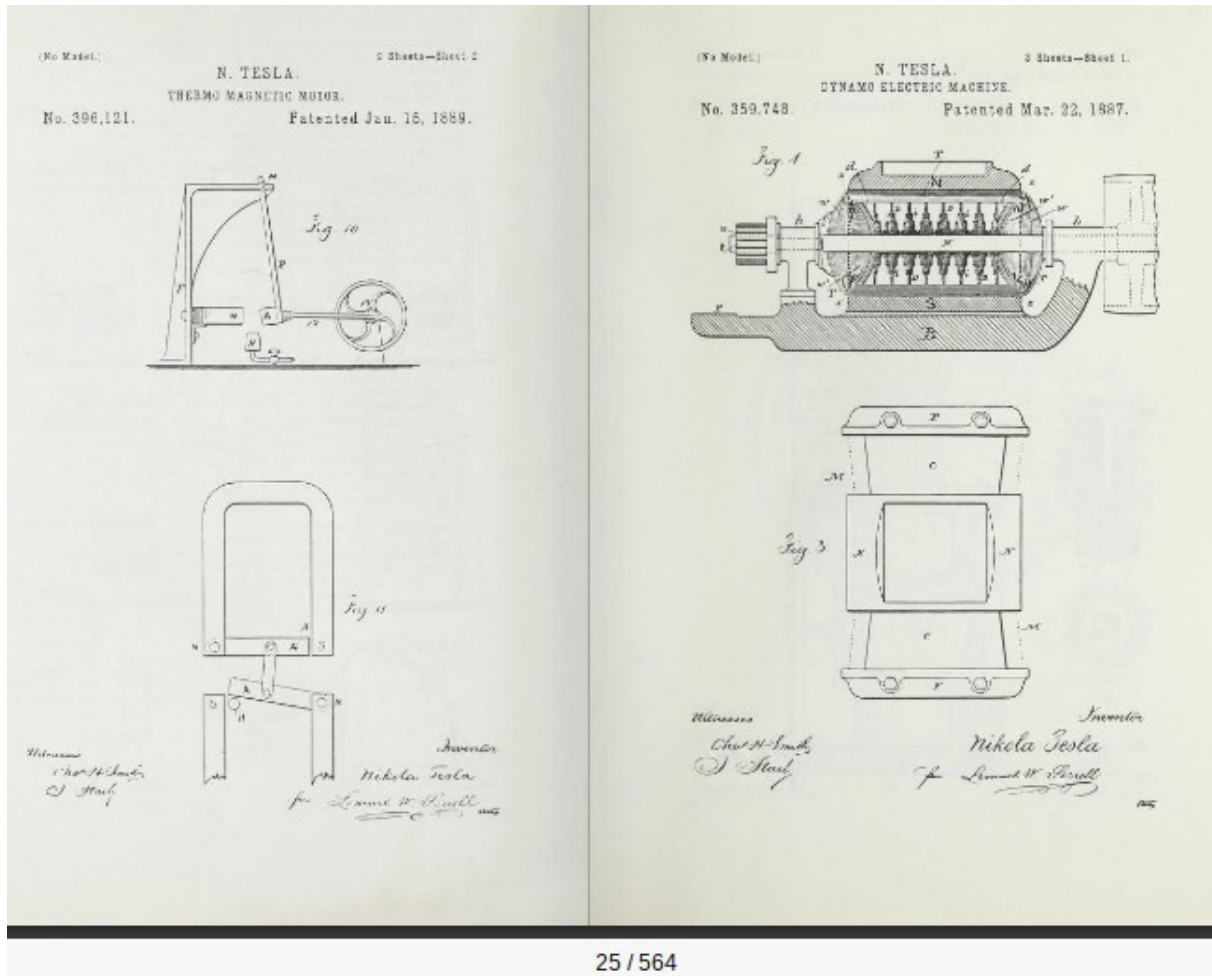
Inventor

Nikola Tesla

By W. B. Smith
att.

27/564

THE COMPLETE PATENTS OF NIKOLA TESLA



THE COMPLETE PATENTS OF NIKOLA TESLA

core in the helix, or the armature may assume the form of a solenoid-core, there being no permanent core within the helix.

Fig. 6 is an end view, and Fig. 7 a plan view, illustrating my improvement as applied to a swinging armature, A, and a stationary permanent magnet, N S. In this instance I apply the heat to an auxiliary armature or keeper, T, which is adjacent to and preferably in direct contact with the magnet. This armature T, in the form of a plate of sheet-iron, extends across from one pole to the other and is of sufficient section to practically form a keeper for the magnet, so that when this armature T is cool nearly all the lines of force pass over the same and very little free magnetism is exhibited. Then the armature A, which swings freely on the pivots M in front of the poles N S, is very little attracted and the spring S pulls the same away from the poles into the position indicated in the drawings. The heat is directed upon the iron plate T at some distance from the magnet, so as to allow the magnet to be kept comparatively cool. This heat is applied beneath the plate by means of the burners H, and there is a connection from the armature A or its pivot to the gas-cock G or other device for regulating the heat. The heat acting upon the middle portion of the plate T, the magnetic conductivity of the heated portion is diminished or destroyed, and a great number of the lines of force are deflected over the armature A, which is now powerfully attracted and drawn into line, or nearly so, with the poles N S. In so doing the cock G is nearly closed and the plate T cools, the lines of force are again deflected over the same, the attraction exerted upon the armature A is diminished, and the spring W pulls the same away from the magnet into the position shown by full lines, and the operations are repeated. The arrangement shown in Fig. 6 has the advantage that the magnet and armature are kept cool and the strength of the permanent magnet is better preserved, as the magnetic circuit is constantly closed.

In the plan view, Fig. 8, I have shown a permanent magnet and keeper-plate, T, similar to those in Figs. 6 and 7, with the burners H for the gas beneath the same but the arma-

W acts against a lever-arm that projects from the armature, and the supply of heat has to be partly cut off by a connection to the swinging armature, so as to lessen the heat acting upon the keeper plate when the armature A has been attracted.

Fig. 9 is similar to Fig. 8, except that the keeper T is not made use of and the armature itself swings into and out of the range of the intense action of the heat from the burner H.

Fig. 10 is a diagram similar to Fig. 1, except that in place of using a spring and stops the armature is shown as connected by a link, 12, to the crank 13 of a fly-wheel, so that the fly-wheel will be revolved as rapidly as the armature can be heated and cooled to the necessary extent. A spring may be used in addition, as in Fig. 1.

In Fig. 11 the two armatures A A are connected by a link, so that one will be heating while the other is cooling, and the attraction exerted to move the cooled armature is availed of to draw away the heated armature instead of using a spring.

I have shown in the drawings several ways of carrying out my invention; but said invention is not limited by any particular form, arrangement, or construction of devices.

I claim as my invention—

1. The combination, with a swinging body under the influence of magnetism, of a burner or other source of heat acting to vary the magnetism, and a spring or other power to move the swinging body in the opposite direction to the action of the magnetism, substantially as set forth.
2. The combination, with two or more armatures connected to each other, of magnets to influence such armatures, and burners or other sources of heat to vary the magnetic action and cause the armatures to move, substantially as set forth.

Signed by me this 29th day of March, 1886.

NIKOLA TESLA.

Witnesses:
GEO. T. PINSKEY,
WALLACE L. SERRELL.

(No Model.)

N. TESLA.
THERMO MAGNETIC MOTOR.

2 Sheets—Sheet 1

No. 396,121.

Patented Jan. 15, 1889.

